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VICE-ADMIRAL A. P. RYDER, in the Chair.

ON COAST FOG-SIGNALS.

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IN the course of discussion on a paper "On the Loss of Life at Sea," read before this Institution in May 1866,* Admiral Halsted thus graphically described the case of those who have "the anxiety of "navigating a ship in our narrow waters, in our foggy and dark "climate. You come in from sea, not having had observations for "three or four days, you take soundings in the channels; but where "on earth you are, you do not know, and your only chance of correctly "knowing where you are when knocking about in the fluctuations and "changes of the tide, is to get well in with some well-known spot of "land; and the safest spot which you can get in with, under these "circumstances, is some danger light. If it is thick weather, you are "bound to run in to some light until you make it. After you run in "a certain distance, you know by your soundings that you are nearing "the land, and you go creeping on like a moth round a candle till you "strike upon the rocks round the danger light, which is erected for "your safety." I have quoted these words at length, because it is precisely under the circumstances which they describe that the service to be performed by Coast Fog-signals commences. When we consider the frequency of the occurrence of foggy and other thick weather on our coasts, and the vast numbers of vessels, engaged in coasting or over-sea traffic, which require a warning or guide during such weather, the immense importance of these signals becomes apparent; and it is surprizing how slight and superficial is the knowledge in this country respecting them, and how limited their practical application.

The subject of Fog-signals divides naturally into two branches; one relating to the means employed on board of ships, for the purpose either of giving warning of their whereabouts to other vessels, or of communicating intelligence or orders; the other to those employed at

* Journal R. U. S. Inst., vol. x., p. 225.

fixed stations on or near the coast, to serve as guides to navigation, in which respect they are to be regarded as fulfilling the same purpose as lights, at times when daylight or atmospheric obstruction renders the lights useless. The former division of the subject, relating to what may be specially termed Marine Fog-signals,* has been treated-of in Captain Brent's very interesting paper already before this Institution, and will doubtless continue to receive at the hands of naval officers that further investigation which its importance undoubtedly deserves. It is the latter division of the subject, relating particularly to Coast Fog-signals, to which I propose to invite your attention on the present occasion, although most of the instruments to be treated-of are common to both.

These instruments are, gongs, bells, guns, trumpets, whistles, and syrens. I shall proceed to consider each instrument separately, in order to clear the way for a consideration of the whole subject in a general manner.

Gongs.

Gongs are used on board light-vessels, and are struck by hand with a stick having a padded head. With reference to this practice, I am informed that in the East they are sounded by rubbing, which is commenced at the centre, the diameter of the circle of friction being gradually increased until the maximum sound is elicited; and it is said that a much greater volume of sound is produced by this means than by striking, whilst the risk of injury to the gong is of course diminished. How far this instrument can be heard in fog, or during thick or snowy weather, is not known. M. Reynaud, whose experience and care as an observer entitle his opinion to great weight, states that its range scarcely exceeds 550 yards—meaning probably its mean effective range. Gongs have been heard at a greater distance, but probably under exceptional and favourable circumstances. Their use ought unquestionably to be restricted to that of guides to the navigation of short channels, harbours, and similar situations, where great range would be useless; and they should never under any circumstances be depended-upon as sea-signals where great range is requisite.

Bells.

Bells are extensively used as fog-signals, and their employment for this purpose dates from a remote period. Those at present in use vary much in weight, ranging from 3 cwt. to upwards of 2 tons.

The experiments made in France in 1861—62 by the engineers of the Corps des Ponts et Chaussées afforded some valuable practical information upon the subject of the striking of bells. It was ascertained that the range of their sound increases with the rapidity of the strokes, the relative distances for 15, 25, and 60 strokes per minute being in the ratio of 1, 1·14, and 1·29. Experiments were also made respecting the effect of a hemispherical iron reflector, backed with Portland cement, in increasing the range of a bell, and it was ascertained that the use of such a reflector increased the mean range in the ratio of

* Journal, vol. xv, page 136 *et seq.*

147 : 100 over a horizontal arc of 60°, beyond which its effect gradually diminished.

In the Admiralty notification of the fog-bell at Whales Back, New Hampshire, it is stated that it should be heard at a distance of from a quarter of a mile to four miles, according to circumstances. But this is only an estimate. Respecting the range of a bell during fog, as ascertained from actual observation, I have been unable to discover any reliable evidence, save in two instances quoted by Mr. Cuningham, Secretary to the Commissioners of Northern Lights, in a Paper on Fog-signals.* It is therein stated, that a bell at Howth, weighing $2\frac{1}{4}$ tons, struck 4 times per minute by a 60-lb. hammer falling 10 inches, has been heard only 1 mile to windward against a light breeze during fog; and that a similar bell at Kingstown, struck 8 times per minute, has been heard at a distance of 3 miles so as to be useful to a steamer, enabling her to make the harbour from that distance. In the latter instance it is probable, either that there was no wind, or that the steamer was to leeward. But it is to be remembered that those two bells are unusually large, in fact they and the one at Ballycottin are the largest on our coasts, the only others which at all approach them in weight being those at Start Point and South Stack, weighing respectively $31\frac{3}{4}$ cwt. and $41\frac{1}{2}$ cwt. If, then, a bell of that great size is efficient, against a light breeze, to a range of only 1 mile, what, under similar circumstances, may be expected to be the range of the comparatively light bells of from 3 to 7 cwt. employed as fog-signals at our rock lighthouses, which are outlying danger stations? In the paper above mentioned, speaking of the fog-bells at the Bell Rock and Skerryvore with reference to such a signal at rock lighthouses generally, Mr. Cuningham says—"It is the only one which seems to "be suitable for such localities, but its efficacy seems to me, in the "present state of our information, to be very doubtful. I doubt if "either bell has been the means of saving a single vessel from ship-"wreck during fog. I cannot recall . . . . any instance of a vessel "reporting that she was warned to put about in fog, or that she ascer-"tained her position in any respect by hearing the sound of the bell in "either locality, though it is quite possible that such instances may "exist."

In the case of a rock lighthouse, there is another important circumstance to be taken into account:—Owing to the situation of most of these structures, they are exposed during stormy weather to very heavy seas, which run green water up the shaft of the tower and not unfrequently fly clean over the gallery-course. The bell is usually suspended from cantilevers at or about the level of the gallery-course, and would, if placed on the most exposed side of the building, be liable to be carried away—a thing which actually occurred in 1860 at the Bishop Rock—and it is therefore placed on the most sheltered side. Hence it follows that its sound is intercepted and deadened by the tower towards the most exposed quarter, generally the seaward side, where it is most required to be heard.

* February, 1863. Trans. Roy. Scottish Soc. of Arts, vol. vi.

Guns.

The range of the sound of cannon is commonly supposed to be very great, and there are on record well-authenticated cases in which artillery has been heard at a surprizing distance. It would therefore seem natural to infer that cannon must be serviceable as a fog-signal. That they are so in many instances is not to be denied. Admiral Sir A. Milne informs me that he has often gone into Halifax harbour, in a dense fog like a wall, by the sound of the Sambro fog-gun. This is a fair test of efficiency. Still, there are some considerations tending to show that implicit reliance ought not to be placed on the efficiency of guns in all cases. In the first place it is to be remembered that we are apt to be strongly impressed by exceptional and startling results, and to overlook the very much larger number of instances in which the results are comparatively trifling. In the next place, it is a well-established fact that even in calm and clear weather the range of the sound of guns is extremely variable. In the Trinity House experiments off Dungeness, in January 1864,* made in fine weather, with calms and light airs, the report of an 18-pounder with 3 lbs. of powder was faint at 4 miles. In those of 1865†, made in similar weather with the same description of gun, the report was distinctly audible at 7 miles. And Dr. Gladstone‡ has recorded the remarkable irregularity of the noise of a gun in some experiments at Holyhead. It is unnecessary to multiply examples of a phenomenon which must be familiar to all who have had much experience. Such being the case during calm weather and in the absence of fog, it needs no great amount of reflection to perceive that, during fog, even in the absence of wind, the probability of irregularity and uncertainty is greatly increased. The report of guns fired at sea as signals of distress can frequently be heard on shore, at a considerable distance, and during very thick weather and through the roar of breakers; but signals under these circumstances are generally made to windward of the hearers.

There is a practical disadvantage in the use of a gun at or close to a lighthouse, in the effect of the concussion upon the building and apparatus. I am informed by the Rev. Dr. Robinson, F.R.S., that the glass of the Duncannon lighthouse was generally shattered when the 68-pounders in a battery close by were fired in target practice. The same thing occurred frequently at the lighthouse on Staten Island.§ A similar result might be produced by a fog-gun, and, if it took place at night, would be an extremely serious matter, involving perhaps the extinction of the light.

The three fog-guns on the English coast are iron 18-pounders, with a charge of 3 lbs. of powder, and are fired at intervals of 15 minutes. The gun at Rathlin Island, having a similar calibre and charge, is fired every 20 minutes. Brass guns would probably be more efficient as a signal than iron ones, as they give a much sharper report; but they would cost more in the first instance.

* Parliamentary Paper, 1864. Commons, No. 125.
† T. Stevenson, "Lighthouse Illumination," 2nd ed., p. 198.
‡ Proceedings Royal Institution, vol. iv., p. 54.
§ Report of U. S. Lighthouse Board, 1871, p. 20.

The average duration of fogs at the English gun-stations is nearly 6 hours, and they not unfrequently last 20 hours at a stretch. Even with two gunners, therefore, the efficient service of the gun entails very severe labour, and the risk of remissness and irregularity must be considerable.

The first cost of a fog-gun establishment will vary according to locality and other causes, but it may be roundly assumed to be £1,000, including two 18-pounder guns, and all the necessary buildings on a moderate scale. The average working expense of the English gun-signals, including wages, allowances, stores, and ammunition, is at the rate of £18 1*s*. 10*d*. per 24 hours of work.

Trumpets.

At the risk of appearing somewhat inconsistent with my design of treating exclusively of fog-signals for coast purposes, I must refer briefly to one intended for use on board ship, because it is apparently the earliest example of the application of machinery to the blowing of fog-trumpets. This was the "Telephone" of the late Admiral J. N. Tayler, submitted to the Admiralty in 1844. The sound was produced by pipes, having metallic reeds, and blown by air condensed into a receiver by means of air-pumps worked by a winch and cranked axle. It was estimated by the inventor, that this instrument would have an effective range of 6 or 8 miles in foggy weather, and that by means of a parabolic reflector a still greater range could be attained. Whether these expectations were fulfilled, I cannot say, having been unable to discover any report upon the experiments which it is believed were tried; but it is important to observe that we have here the metallic reed, and the compression of air by machinery. Admiral Tayler stated that his attention was first called to the adaptation of this instrument for the purpose of marine communications by an Alarm which he heard in France. M. Reynaud, to whom I mentioned this circumstance, has endeavoured to discover some trace of the latter apparatus, but without success.

The metallic reed, and the use of air condensed by machinery, reappear in the fog-trumpet invented by an American gentleman, the late Mr. C. L. Daboll; and his apparatus, erected in 1851 at Beavertail Point, R. I., by the United States Government, affords the earliest example of its actual employment in practice. The machinery, which was moved by a horse, was very simple, and was applied to the revolution of a cranked axle driving two 3-inch air-pumps. The condensed air was stored in a 225-gallon receiver, on which was fixed the trumpet, and the air was admitted to the reed by a valve regulated by a cord and lever. The initial pressure at which the trumpet was sounded was about 40 or 50 lbs. per square inch. The recorded performances of this apparatus* are surprizingly good. During dense fog and against a light breeze, it was heard distinctly at a distance of 6 miles on shore; and Captain Walden, U. S. Revenue Service, who officially examined

* Report of the United States Lighthouse Board, 1852.

and reported upon it, heard it distinctly at 2½ miles, in a rough sea, with a strong cross wind. The practical value of this instrument was promptly recognized by the U. S. Government, and no time was lost in erecting similar ones at different points on the coast. Improvements in details were at various times introduced by Mr. Daboll: the action of the valve regulating the duration of the blast was made automatic; the trumpet was made to revolve automatically, so as to distribute the sound over any required arc; the use of wires or rods was introduced, as a means of opening and shutting the valve when want of space or other circumstances necessitated the placing of the trumpet at a distance from the condensing apparatus; and engine-power was substituted for horse-power to drive the machinery. These matters formed the subject of a patent taken out by the inventor in 1860 in the United States, and in 1863 in this country.

In a Paper read last year before the Institution of Civil Engineers,* I stated that Daboll's trumpet was not constructed to vibrate in unison with its reed, but acted merely as a condenser and conductor of the sound. Some months after that Paper was read and printed, I met with a Report of the United States Lighthouse Board,† in which distinct mention is made of the tuning of the reed in unison with the trumpet. Whether the instrument was originally so designed, is quite immaterial, few if any inventions being produced in the first instance in such perfection as to be susceptible of no improvement. But it is of importance that the correction should be made in as public a manner as the mis-statement, not merely for the sake of accuracy, but also in justice to the memory of Mr. Daboll, whose name is so honourably associated with the first application of the trumpet to practical use as a fog-signal.

Daboll's trumpets are classified according to size, those in most general use being of the second and third order, which are respectively of the following dimensions:—Axial length, 9 ft. and 4 ft. 6 in. Diameter at small end, 2¾ in. and 2½ in. Diameter across mouth, 2 ft. and 1 ft. 9 in.

In 1865 a second-order Daboll's trumpet was established at Dungeness by the Trinity House of London. A third-order experimental one which had previously been set up there, but had not been notified for use as a fog-signal, was placed on board the Newarp light-vessel in 1868, where it is now sounded during fog. In 1868 a second-order one was established at St. Catherine's. The Newarp trumpet is sounded at an initial pressure of about 12 lbs. and a terminal pressure of about 9 lbs., those at Dungeness and St. Catherine's at an initial pressure of 20 lbs. and a terminal pressure of about 5 lbs. I am not aware of any observations being made, or any record kept, of the range of their sound during fogs. It is said that the Newarp trumpet can be heard at 5½ miles distance, during foggy weather and against a light air, but not during very dense fog or against a moderate breeze.

In 1866 a Daboll trumpet of the third order was established at the mouth of the Clyde by the Cumbrae Lighthouse Trust. For the follow-

* Minutes of Proceedings, vol. xxxii. † Washington, 1868.

ing particulars relating to this fog-signal I am indebted to Mr. Graham, the Treasurer and Superintendent to the Trustees. A Report from the keeper mentions two instances, out of many which have been prominently brought under his own observation, of the valuable services it has rendered to navigation:—"A steamer, whose captain was well "acquainted with the navigation of the channel [of the Firth of Clyde], "in coming in from sea was enveloped in fog in good daylight, and got "so completely bewildered that he ran up on the west side of Bute, as "if he had intended to proceed up Loch Fine; immediately on the horn "starting he recognised his mistake, put his steamer about, and headed "direct up under the fog-signal house. The second instance was in "the case of a schooner, whose master was also specially well acquainted "with this part of the channel, and, getting surrounded with fog, was "heading direct in to the Arran shore; immediately on hearing the "horn away to the eastward he put his vessel about, and, as he described "it to me, could have run his vessel into the landing port at the light-"house. Many similar instances could be given, but the foregoing "may suffice. Further, I have frequently asked both captains and "seamen, and, without exception, their high opinion of its value is "universal." The same Report states that the signal has been heard, during fog, at from 7 to 9 miles against the wind and from 12 to 14 miles down the wind, with light and moderate breeze; and from 3 to 5 miles against a very strong breeze or moderate gale. It is added, that the persons who heard the signal at these distances were either in a sailing vessel on a quiet day or were otherwise free from noise—"it "might be quite different in a steamer under weigh, where the clatter "of machinery and the hissing of steam would render distant sounds "more difficult to be heard." And in a subsequent Report the keeper observes that the examples which he gave were the extreme limits of range which had been reported to him, and that for general practical purposes the horn will not always be heard so far.

The foregoing testimony is valuable as being taken from observations made, not on an occasion selected for experiment, during clear weather and with smooth sea and no wind, but in actual practice under unfavourable conditions of wind and weather; and it derives additional weight from the evident care with which attendant circumstances have been taken into consideration. This trumpet is sounded at an initial pressure of 8 lbs. and a terminal pressure of $4\frac{1}{2}$ lbs.

The cost of the Daboll trumpet and the caloric engine, in duplicate, at St. Catherine's, including expense of erection, was £1,338; and an engine-house and keeper's dwelling, of the substantial character of the buildings there, would cost about £1,500. The engine and apparatus erected at Cumbrae cost £600, and the engine-house £400. The working cost of the St. Catherine's signal in 1869 was at the rate of £6 4*s*. 5*d*., and that of the Cumbrae signal £5 14*s*. 6*d*., per 24 hours of work, including every expense but repairs, which were in each case estimated at about £10 per annum.

The machine generally employed for condensing the air is Ericsson's caloric engine, the use of which has been adopted from America together with the trumpet. It possesses several features which recommend

it for the purpose. It consumes very little fuel—about 12 lbs. of coke per hour; is free from danger of explosion; and, when in good condition, can be started to work in about half an hour. The importance of the latter feature will be appreciated by those who know how suddenly a fog sometimes comes on, and how necessary it is that the fog-signal should commence sounding without delay. It has however been found by experience in America, that the caloric engine is not satisfactory. A Report made in 1869 to the Minister of Marine and Fisheries at Ottawa, by the agent of the department at Halifax, stated:—"One "very great objection to these instruments [Daboll's trumpets] is the "use of the caloric engine instead of steam. They appear to work "very well for a time, but once the machinery from any cause gets out "of repair, no reliance can be placed on its efficient working for any "length of time." The apparatus of the trumpets at Sambro and Cranberry Island, N.S., established in 1865, required almost continual repairs after about two years' working. The Engineer of the Department of Marine and Fisheries states:*—"The expenses for repairs, and "the frequent stoppages to make these repairs during the four years "they continued in use, made them expensive and unreliable. The "expense is perhaps the smallest objection. The frequent stoppages "during foggy weather made them sources of danger instead of aids to "navigation." After giving these signals a very fair trial, it was at length determined to abandon them, and last autumn a gun was established at Sambro, and a steam-whistle at Cranberry Island. Respecting the efficiency of the trumpets themselves, the 1869 Report of the agent, already quoted, states:—"The sound of these trumpets has "become much deteriorated during the last year or so."

The change of the signals at Sambro and Cranberry is not a solitary case. At several stations on the coast of the United States the steam-whistle has been substituted for the trumpet. The risk of stoppage of the signal by the breaking-down of the caloric engine is provided against at Dungeness and St. Catherine's by a duplicate engine being kept in readiness.

A Daboll trumpet was established in July 1871, at the Howth Bailey lighthouse on the east coast of Ireland. I have not heard any particulars as to its efficiency. It is worked by a caloric engine, respecting which Captain Hawes, R.N., Inspector of Irish Lights, states:—"The Bailey being lit with gas, I have found it exceedingly "convenient to use it instead of coal for driving this engine, and "would have continued to do so, had the gas-holder there been of "sufficient capacity to admit of it."† This is, so far as I am aware, the first example of the application of gas to the heating of the caloric engine; and it is probable that with such fuel the fire-box (the weak part of the engine) would not be so soon burnt-out as where coal or wood is used, and that the engine would consequently be less liable to get out of order.

The trumpet of Professor Holmes, sounded by condensed air, is

* Report to Deputy of Minister of M. and F., Ottawa, 10th January, 1872.
† Report to Commissioners of Irish Lights, 10th April, 1872.

intended to distribute its sound uniformly over an arc of 90° instead of being strongest only in the line of its axis, so that four of them shall form a holophone of 360°; and two light-vessels constructed for China from the designs of Mr. J. N. Douglass, M. Inst. C.E., are thus fitted. The light-vessel at Seven Stones was fitted last November with a Holmes trumpet, worked by a caloric engine.

The lighthouse station at Souter Point is provided with Holmes's signal. The trumpets, two in number, are constructed to sound over an arc of 180°, corresponding with the illuminated arc of the light. The air is condensed by the steam engine employed for the magneto-electric light. The condenser and trumpets are distant about 350 feet from the air-pump, and the sounding of the trumpets at regular intervals is automatically effected by a tumbler, which falls over and opens the valve to the trumpets when the pressure rises to 30 lbs. When the pressure is reduced by the blast to 28 lbs., the tumbler falls back and closes the valve until the pressure again rises to 30 lbs. The interval between the blasts, or in other words the time requisite to recover the 2 lbs. of pressure expended, depends upon the capacity of the condenser, which is regulated by the introduction of water.

On applying to the Committee of Lloyd's, they most obligingly wrote to their agent at North Shields to inquire respecting the performance of this instrument, and I am informed that "he has ascertained, on "good authority, that the fog-trumpet . . . . is of great use."* This is satisfactory, as showing the general estimation in which the signal is held by nautical men. It would have been more so, if the precise conditions of wind and weather, and the distance at which the signal was heard, could have been added.

There is also another fog-trumpet, by Anderson, which is established as an auxiliary instrument at Beaver-tail, R.I., and at Long Island, but I have as yet received no details respecting it.

Whistles.

The use of the hemispherical or locomotive whistle as a coast fog-signal appears to have been first suggested by the late Mr. A. Gordon, M. Inst. C.E.,† who proposed to employ air or steam for sounding it, and to place it in the focus of a reflector or group of reflectors in order to concentrate its sound into a powerful phonic beam. The sharpness and shrillness of the whistle were in his opinion its chief recommendations. "When you get a shrill sound high in the scale," he says, "that "sound is carried much further than a lower note in the scale."

The honour of being the first to apply this instrument in practice belongs to the late Mr. C. L. Daboll, who in 1851 erected one at Beaver-tail Point for the United States Government. It was sounded by condensed air, the machinery being the same as that used for the trumpet, in combination or alternation with which it appears to have been employed, and, like that instrument, its performance was efficient

* Secretary of Lloyd's to the Author, 28th March, 1872.
† Evidence before Select Committee on Lighthouses, 1845.

and successful. It was distinctly heard, during dense fogs, at a distance of from 6 to 8 miles, in the town of Newport, when there was considerable noise of carriages in the streets. Captain Walden reported very favourably upon it; and the President of the United States Lighthouse Board has placed upon record, from personal observation, his opinion of its great practical value.* The apparatus, having been tested and approved, was at once adopted by the United States Government, and immediate arrangements were made for the erection of four at various points on the coast.

In 1854, Mr. Robert Foulis, of St. John's, New Brunswick, proposed† the employment of the steam-whistle as a fog-signal; and in 1860 was erected the now famous steam-whistle at Partridge Island, St. John's harbour, which may be regarded as the archetype of all subsequent ones. It was erected under the superintendence of Mr. T. T. Vernon Smith, and this type of apparatus is frequently designated by the name of the "Vernon Smith whistle." It is extremely simple in its details. The boiler is tubular, having a superheater, connected with which is the whistle, and the sounding of the instrument is automatically regulated. The apparatus was patented in Great Britain in 1861 by Mr. Barker, for Mr. Vernon Smith.

Respecting the efficiency of this instrument, it is stated:‡—"With a "pressure of from 90 to 95 lbs. the whistle can easily be heard in calm "weather a distance of 6 or 7 miles, and has been heard by a steamer "in a heavy gale, and sea running high, at a distance of $5\frac{1}{2}$ miles to "windward, but it was then not audible till the paddles were stopped." Captain Malcolm, R.N., officially reported in 1863 that, from experiments made by him, in which the sound of the whistle was audible up to 3 miles' distance, against a moderate breeze (4) and during dense fog, he infers that in such weather the sound may fairly be supposed to have a radius of from 3 to 6 miles.§

The use of steam has now, I believe, entirely superseded condensed air for sounding coast fog-whistles in America, and these instruments are extensively employed, both in the United States and in the Dominion of Canada.

In May 1869, the Commanding Officer of H.M.S. "Minstrel" officially examined one at Cape Forchu, Nova Scotia, and made a Report to the Admiral on the station, of which the following is an extract:—"After "communicating with the keeper of the fog-whistle . . . . I "weighed and proceeded head to wind, stopping at intervals to listen to "the whistle, the sound of which was distinctly heard 7 miles and "finally ceased 8 miles off. The wind at the time was S.S.W., force "4, weather foggy. The distance was calculated at first by cross "bearings, and, after the fog set in, by the patent log." The Report goes on to state that, whilst the observations were being pursued on the following day, the engine of the whistle broke down in consequence of a gland on the feed-pump giving way. The keeper not being pro-

* Report of the United States Lighthouse Board, 1852.
† In "The Morning News," 22nd October, 1854.
‡ Report by Commissioner of Public Institutions, N.B., 1864.
§ Report to the Admiral on the Station, August, 1863.

vided with the means of repairing damages, the experiments had to be discontinued. Such a contingency is now provided against by the supply of duplicates of certain parts of the machinery, but the Engineer of the Department of Marine and Fisheries states* that "so far "in practice they have not been put in use."

The subjoined particulars, although of considerable length, are too important and interesting to be omitted:—

"The following statement of results obtained from Steam Fog "Alarms in use in the Dominion of Canada, and the ranges given, are "from actual observation, and are substantiated by the testimony of "numbers of masters of steam and sailing vessels, and others engaged "in navigating the waters of the Dominion and the United States.

"The Steam Fog Alarm on Partridge Island, at the entrance to the "harbour of St. John, N.B., is heard, under favourable conditions of "the atmosphere and light winds, 5 miles to windward and 9 miles to "leeward; and under unfavourable circumstances and strong winds, "3 miles to windward and 7 miles to leeward. Steamers and sailing "vessels making the port of St. John during snow storms, thick, and "foggy weather, run for the harbour with confidence, relying on the "sound of the whistle of the Alarm for distance and position. The "whistle of this Alarm is 5 inches diameter, steam pressure 80 lbs. "Blast 10 seconds duration, once in each minute.

"The Steam Fog Alarm at Cape Forchu, entrance of Yarmouth "harbour, N.S., has frequently been heard (overland) at Barrington, "a distance of 30 miles from the Alarm, and at Seal Island, N.S., "26 miles from the Alarm, at times when the state of the atmosphere "was favourable for the conveyance of sound, wind light. This "Alarm is heard by persons on steamers and other vessels 8 miles to "windward in a strong breeze; in light winds 10 and 12 miles to "windward. The whistle of this Alarm is 8 inches diameter, steam "pressure 75 lbs. Blast 10 seconds duration in each minute.

"The Steam Fog Alarm on Seal Island, off the S.W. point of Nova "Scotia, is heard on the mainland 18 miles distant. The masters of "steamers plying between Boston and Portland, U.S., and Halifax "N.S., report that they run for the Alarm on Seal Island, and "generally hear the Alarm from 40 to 50 minutes before they make "the island. Fishing vessels frequent the waters around Seal Island, "and the fishermen report that the Alarm is invaluable, as they can "by the sound of the Alarm (knowing its position) shape their course "to clear the reefs lying off the island, or make a harbour on the "mainland, in dense fogs and thick weather. Before the Alarm was "put on this island, the fishermen were obliged, in stormy weather with "fog, to run to sea. The whistle of this Alarm is 8 inches diameter, "steam pressure 75 lbs. Two blasts (of 5 seconds duration each, with "an interval of 5 seconds between the blasts) in each minute.

"The Steam Fog Alarm at Point Lepreau in the Bay of Fundy has "been heard in foggy weather and snow-storms 25 miles along the "coast, 15 miles inland, and 20 miles at sea, under favourable condi-

* Report, *ubi sup.*, 10th January, 1872.

" tions. The International Company's steamers, owned in the United " States, pass Point Lepreau, the site of this Alarm, 8 times a week in " the season when fogs are prevalent. The officers of these steamers " report that they hear the Alarm from 35 to 40 minutes before the " steamer arrives abreast of the Point. The speed of these steamers is " fully 12 miles an hour (they say 13), consequently they hear the " Alarm 7 or 8 miles distant, the steamer being at full speed, and " making the noise usual to paddle steamers running at full speed. " The whistle of this Alarm is 8 inches diameter, steam pressure 75 lbs. " Two blasts (of 5 seconds duration each, with an interval of 5 seconds " between the blasts) in each minute.

" The Steam Fog Alarm at the entrance of Digby Gut, N.S., put in " operation 1st January 1872, was heard from the deck of the steamer " 'Empress' 45 minutes before she passed the site of the Alarm in " entering the Gut. Captain Leary judged the Alarm 6 miles distant " when first heard; the time and speed of the steamer made the " distance nearly 7 miles; the wind was very strong at the time, " blowing in a direct line from the steamer towards the Alarm, the " steamer running before a heavy sea, pitching and rolling, the " atmosphere very cold and dry, wind N.N.W., all unfavourable con- " ditions for hearing the sound of the whistle of the Alarm. This " Alarm was being tried on this occasion for the first time, with a " pressure of 65 lbs. per square inch. Later the same day, the Alarm " was distinctly heard by the captain, crew, and passengers of the " steamer, at Annapolis, N.S., 20 miles distant from its site and at a " right angle to the direction of the wind. The whistle of this Alarm " is 8 inches diameter, steam pressure 75 lbs. Blast 8 seconds dura- " tion in each minute. The boilers of the Alarms already mentioned " use fresh water.

" The Steam Fog Alarm on the iron light-ship at Red Island Shoal, " River St. Lawrence, has been heard 3 miles to windward and 15 miles " to leeward. The whistle of this Alarm is 10 inches diameter, steam " pressure 60 lbs., and gives a blast of 10 seconds duration in each " minute. The boiler of this Alarm is constructed to use salt water."

Then follows a description of the whistle at Anticosti, diameter 8 inches, steam pressure 80 lbs.; and at Cranberry Island, 10 inches diameter, steam pressure 60 lbs., but it is added that no definite information had been obtained as to the distances at which they can be heard. The Report then proceeds:—

" The average consumption of fuel is 1,000 lbs. of Anthracite coal or " 1,120 lbs. of Welsh coal, in 24 hours. The Welsh coal furnished to " some of the Alarms last season cost $5·00 [20*s.* 10*d.* stg.] per ton " of 2,240 lbs., making cost of fuel for 24 hours $2·50, [10*s.* 5*d.* stg.] " exclusive of carriage and other charges.

" The cost of a Steam Fog Alarm with an 8-inch whistle, completed, " ready for operation, is $1900·00 [£395 16*s.* 8*d.* stg.]. When the boiler " is intended to use fresh water, the weight is 3 tons. This sum " includes the steam-pump, which is used as a fire-engine if required. " The building for the Alarm, conveying to place of erection, pro- " curing water, and outfit required, are not included, as these expenses " are governed by circumstances of distances, site, &c.

"The cost of an Alarm with a 10-inch whistle, with the boiler to use "salt water, is $3000·00 [£625 stg.]. . . . .

"The duration and frequency of the signals as arranged, have in "practice been found sufficient. The United States coasting steamers "are generally very swift, and enquiry by the American Government "was made of the masters of these steamers in this matter, and the "replies stated that they considered the signals as arranged by the "Dominion Government quite reliable and sufficient."*

During the years 1862–3–4–5, the Partridge Island whistle was in operation on an average 888 hours 47 minutes in each year, at an average cost, including wages, stores, repairs, and every expense, of £3 13*s.* 0*d.* per 24 hours of work.† I have no details of the working cost of the other whistles; but, with perhaps the exception of that at Anticosti, it probably does not materially differ from the above.

* Engineer's Report to Deputy of Minister of M. and F., Ottawa, 10th January 1872.

The following details of cost of the fog-signal stations mentioned in the above Report, are of considerable practical interest. The cost of the apparatus is higher than stated in the Report, probably covering the expense of outfit, stores, &c. I have reduced the prices in this table, as well as those in the Report, to sterling at 4*s.* 2*d.* per $.

	£	*s.*	*d.*	£	*s.*	*d.*
Yarmouth Steam Fog-whistle :—						
Apparatus	432	5	10			
Buildings	256	5	0			
Plans, Specifications, and Incidentals	30	8	4			
				718	19	2
Seal Island Steam Fog-whistle :—						
Apparatus	522	5	10			
Buildings	361	9	2			
Reservoir	275	8	4			
Plans, Specifications, &c.	17	10	0			
				1176	13	4
Point Lepreau Steam Fog-whistle :—						
Apparatus	458	2	6			
Buildings	258	19	2			
Digging Wells	36	5	0			
Plans, Specifications, &c.	36	5	0			
				789	11	8
Digby Steam Fog-whistle :—						
Apparatus	578	6	8			
Buildings	364	11	8			
Plans, tracings, &c.	18	6	8			
				961	5	0
Cranberry Steam Fog-whistle :—						
Apparatus and Buildings..	..	..		2114	11	8
Anticosti Steam Fog-whistle :—						
Apparatus	791	13	4			
Buildings	729	3	4			
Plans, Specifications, &c.	40	4	2			
				1561	0	10
Red Island Light-vessel Steam Fog-whistle :—						
Apparatus	817	5	10			
Plans, Specifications, &c.	15	17	7			
				833	3	5

† Secretary of Commissioners of Public Institutions, N.B., to Controller, 18th August 1866.

In 1869 a steam-whistle apparatus, on the American principle, was established at Girdleness by the Aberdeen Harbour Commissioners, under the superintendence of their Engineer, Mr. W. D. Cay, M. Inst. C.E. He informs me that the whistle is 6 inches diameter, sounded at a pressure of 60 lbs., and that the signal is said to be very useful to captains of steam-vessels seeking the harbour in foggy weather. I have not, however, heard of any experiments being made as to its effective range.* Its total working cost in 1870 was at the rate of £4 5*s.* 1*d.* per 24 hours of work.

Several trials of steam-whistles have been from time to time made by the Commissioners of Irish Lights; but considerable hesitation as to the propriety of adopting such a fog-signal appears to be caused by the fear of confusion arising from the use of similar instruments by steamers and locomotives.† Such confusion, if found to occur in practice, would undoubtedly be a serious objection; but the extensive adoption of this signal on the American coast, and the absence of any evidence of accidents having occurred from that cause, render it almost certain that the difficulty is more formidable in appearance than in reality. Mr. T. Stevenson, M. Inst. C.E., one of the Engineers to the Commissioners of Northern Lighthouses, in noticing‡ a similar objection, points out that it may be obviated by employing a whistle producing a peculiar and distinctive sound, and by adopting a certain general uniformity in the blasts and silent intervals of the signal.

In 1865 a plan was proposed by Mr. H. T. Humphreys, M. Inst. C.E. (to which he gave the name of "Clamor Æstus"), for sounding a whistle by a strong percussive blast of air, obtained by the fall of a heavy weight upon a piston working air-tight in a cylinder communicating with the whistle. It is stated, that the sudden compression of the air by this means, and the violence with which it would be driven through the whistle, would produce a sound of great shrillness and intensity, entirely peculiar and characteristic. In this opinion I am quite disposed to agree. Mr. Humphreys experimented successfully on the action of the percussive blast;§ but the expense of the construction of a complete apparatus on his principle prevented its trial in actual practice in all its details. This is to be regretted, and not the less so because the plan proposed included an ingenious application of tidal power to the working of the machine.

* The term "effective range" is used throughout this Paper (except where words not my own are quoted) in one sense only, signifying *the actual distance at which, under the most unfavourable circumstances of wind and weather, a signal can always be heard on board a paddle steamer under way in a heavy sea.* Whether the distance be long or short (which depends upon the power of the instrument), that is the "effective range" of the signal, or the signal is said to be "effective" at that range or distance.

I am indebted to Admiral Ryder for pointing-out, that a limit to the strength of the wind against which a fog-signal is to be considered "effective," should be placed at that force beyond which a vessel could not carry sail enough to be manageable—since, if the wind exceeded that strength, the signal could be of no service even if heard.

† Capt. Hawes, Report to Commissioners of Irish Lights, 10th April, 1872.

‡ Trans. Royal Scottish Soc. of Arts, vol. vii., p. 204.

§ Mr. H. T. Humphreys to the Author, 24th January. 1871.

Various methods have been suggested for concentrating and directing the sound of the whistle. The proposal of the late Mr. A. Gordon was, to place the whistle in the focus of the double reflector of Bordier Marcet's apparatus, for the purpose of directing the sound into a horizontal plane, answering to a fixed light; or in a focus common to a group of three parabolic reflectors revolving on a vertical axis, answering to a revolving light of the same number of faces. In 1860 Mr. E. A. Cowper, M. Inst. C.E., laid before the Trinity House of London a proposal to employ a gigantic parabolic reflector or trumpet, having an axial length of from 25 to 40 feet according to the requirements of the case. The trumpet was to be made to revolve over any required arc, corresponding to a revolving light of one face. In 1864 Mr. T. Stevenson devised a peculiar combination of reflecting surfaces, constructed of $\frac{1}{10}$-inch sheet iron, and arranged on the principle of the reflecting prisms of an apparatus for light, viz., that of arresting and sending forth in suitably parallelized rays all the sound emitted by the whistle. This instrument, of which a detailed description is contained in his work on "Lighthouse Illumination,"* and to which he gives the characteristic name of "holophone," was experimentally tried in 1865 by direction of the Commissioners of Northern Lighthouses, with the approbation of the Board of Trade. "The result of these experiments, "which were made with a *low* power of steam, was, that while at "moderate distances of about $1\frac{1}{2}$ mile, the holophone was very much "louder than a naked whistle supplied from the same boiler, the "difference between the maximum distances at which each could be "heard was less than might have been expected from the results "obtained at lesser distances. Thus, while at the distance of about "2 miles the holophone was very much louder, the naked whistle died "out at 3 miles, and the holophone between 3 and 4 miles."†

The practical value of any scheme relating to the collection and distribution of the sound of a whistle or other radiant can only be determined by tentative and careful experiment; and the principal obstacle to be overcome will probably be found to be the difficulty of getting rid of the volume of steam escaping in the act of sounding, which, if suffered to fill the reflecting apparatus, must tend more or less to deaden and stifle the sound.

One of the essential requisites of a fog-signal is, that it shall indicate with tolerable exactness the direction from whence the sound proceeds. Some interesting experiments made by Mr. J. H. Alexander in 1855, showed that with a steam-whistle this could be readily determined within an arc estimated to be of 3° or 4°, at a distance of $3\frac{1}{2}$ miles. The whistle employed had a screw-thread on the stem supporting the upper or inverted bell, which regulated the distance of the sounding-lip from the annular steam-orifice. Mr. Alexander pointed out how necessary it is that the feather-edged sounding-lip should everywhere coincide with the central line of the opening. The importance of this coincidence is strikingly illustrated by a case stated to me by Professor Holmes, of a whistle of French manufacture upon which he made some

* 2nd edition, p. 194–196.

† "Lighthouse Illumination," 2nd edition, p. 197.

experiments, and in which he found that the non-efficient portions amounted to fourteen-fifteenths of the whole circumference. I mentioned this circumstance to Mr. John Bailey, of Salford, whose "steam-roarer" was so favourably noticed in Captain Brent's Paper; and he obligingly tried some experiments with the view of ascertaining whether any portion of his own whistles could be blanked without diminishing the sound—the result of which would have been to confirm the conclusion pointed-to by Professor Holmes's experiment, that all steam-whistles are in this respect defective, and that increased accuracy in the coincidence of the steam-slot and the sounding-lip is required in order to develop the full power of the whistle. Mr. Bailey, however, who intercepted the steam at various points in the circumference, found that the sound of the whistle diminished just in proportion to the length of slot stopped; and the inference is, that the whistle experimented upon by Professor Holmes was unusually defective, or, at any rate, very inferior in accuracy of fitting to the best specimens of English manufacture.

Mr. Alexander's experiments tended to show that the most effective working pressures are from 40 lbs. upwards. His investigations extended over a variety of other practical details connected with the steam-whistle, for the particulars of which I must refer you to his very able and interesting Report.*

Syrens.

The syren is an instrument in which the sound is produced by the alternate passage and stoppage of air or steam by means of a revolving disc or cylinder pierced with holes. The pitch of the note thus produced depends upon the rapidity with which the alternations are made. Several instruments upon this principle, sounded by steam, are now in actual use as fog-signals in the United States.

Last year Mr. Adolphus Brown, of New York, brought out a fog-trumpet on the principle of the syren. This instrument has been highly commended by Professor Henry, as a fog-signal of great power, and has been by him recommended for adoption at four lighthouse stations in the United States.

Of the mechanical construction of the above-mentioned instruments as used in actual practice, and their ascertained range, I am not as yet in possession of sufficient details to enable me to lay before you any definite statements. It may not, however, be out of place to remark, that the sound of the syren is a true musical note of great purity; and that it is a question which has not yet, so far as I am aware, been satisfactorily answered, whether pure notes or discords have the greatest effective range in fog and against wind.

Such, then, are the instruments at present known to us as fog-signals. I say, at present, because other means have been proposed for making those signals, and there is no ground for assuming that we have as yet by any means exhausted invention upon the subject. Nearly half a century ago, M. Colladon demonstrated the possibility of trans-

* "Report on Fog-signals by Steam, addressed to the Committee on Experiments of the U.S. Lighthouse Board," Washington, 1861.

mitting sound through water to very considerable distances; and he ultimately succeeded in so transmitting distinctly audible signals to a distance of upwards of 21 miles. The subject has, down to a recent date, engaged the attention of many eminent scientific men, whose careful researches and hopeful anticipations respecting it sufficiently show that the idea is far from being of such a speculative and unpractical nature as might be supposed. Captain Brent is now engaged in pursuing inquiry and experiment in this direction, and deserves, as he doubtless has, our best wishes for his success.

Reverting, however, to the recognized and established methods of fog-signalling, it will now be proper to inquire to what extent they are severally suited to the requirements of navigation. And this raises the preliminary questions:—What is a fog? In what manner does it affect sound? and, What are the requirements of navigation in connexion therewith?

Fog has been defined as being "the moisture evaporating from the "warm earth, or river, or sea, condensed at once by the colder air," and as "a cloud resting on the earth."* But there is this difference between fog and cloud; that whereas a person may be enveloped for a length of time in some fogs without being sensible of damp, it is altogether otherwise with cloud, a circumstance which will be within the recollection of all who have had much to do with mountaineering. M. Ch. Martins, it is true, asserts that fogs are always more or less perceptibly damp;† but he also quotes the experience of De Saussure and Humboldt on the opposite side of the question. However, whether fogs are characterised by dryness or humidity, it is agreed that they consist either of aqueous globules or of aqueous vesicles, of extreme minuteness, held in suspension in the air. It is possible that the appreciable dryness or moisture of a fog may depend upon the electrical tension of the air thus charged.

Now experience has shown that fog has the effect upon sound, of either deadening and muffling it, or entirely stifling it, at very variable distances; its apparently irregular action in this respect being doubtless regulated by certain laws of order, and depending probably upon the number, density, and elasticity of the particles composing it. It has also been observed‡ that falling rain, and especially falling snow, has a similar and powerful effect upon the transmission of sound. These phenomena have been referred to the general law, that a non-homogeneous body will not vibrate in unison as a whole, or, in other words, will not freely propagate sound; but the precise manner in which that law operates with respect to fog, snow, and similar atmospheric obstructions has not, so far as I am aware, been hitherto explained. The solution

* Dr. Gladstone, "On Fogs and Fog-signals," Proceedings Royal Institution, vol. iv., p. 55.

† "Il est incontestable que le degré d'humidité des brouillards est variable; mais il n'est point encore démontré qu'il existe des brouillards assez denses pour voiler des objets situés à un kilomètre par exemple, et secs au point de n'affecter en rien des instruments psychométriques [hygrométriques?] delicats: à moins que ces brouillards ne soient de la fumée produite par de grands combustions." Martins, Essai sur les Brouillards Secs, p. 228.

‡ Dr. Derham, "De Soni Motu." Phil. Trans., vol. xxvi., p. 24-25.

which I venture to offer was suggested by the following case proposed by the Rev. S. Earnshaw, in treating of the propagation of sound through a tube. He says:—"Suppose a portion of the tube to be filled "with air of a different kind from that which fills the first part " . . . . and to prevent the two airs or gases from mixing, let "them be supposed to be separated by an impenetrable film without "weight and inertia. . . . . Let now a wave be generated in the "first medium and transmitted towards the second; then when it has "reached the common boundary of the media, the velocities of the "particles in contact with the film on both sides will always be equal. "Let U′ be this velocity at any moment, and U the velocity which the "film would have had at that moment, if the second medium had been "the same as the first. Then U—U′ is the velocity lost by the par- "ticles of the first medium by the resistance due to their contact with "the film. In other words, this velocity has been impressed on the "particles of the first medium by the resistance of the film, in the "reflex direction. This gives rise to a reflex wave in the first medium, "which we may consider superimposed on the wind of the original "wave."* The "second medium" here mentioned may be supposed to represent the aqueous particles of fog or mist, or the flakes of falling snow, each of which converts a portion of the direct sound-wave into a reflex wave; and as these particles are exceedingly numerous, they reflect a certain amount of every portion of the wave. The wave, thus weakened, but still travelling onward, is again broken and partially reflected by the particles which it encounters. Those portions of the original wave which strike against the particles of the obstructing medium otherwise than normally to their surface, are reflected not in a direct but in an oblique line, and are again reflected obliquely by other particles. These direct and oblique reflections are repeated again and again, until, if the obstructing medium be of sufficient extent, the whole of the original sound-wave is ultimately broken-up into a confused ripple, possessing less and less of a distinctive character, and less and less power to affect the sense of hearing, according to the extent to which its constitution as a sound-wave has been destroyed.

This view of the case is corroborated by some statements of Professor Tyndall. He says:—"Sounds are also reflected from the clouds. "When the sky is clear, the report of a cannon on an open plain is "short and sharp, while a cloud is sufficient to produce an echo like "the rolling of distant thunder. A feeble echo also occurs when sound "passes from one mass of air to another of different density." He then quotes Humboldt's account of the distant sound of the falls of the Orinoco being much louder by night than by day, and gives the following as Humboldt's explanation of the phenomenon:—"Between him "and the falls lay a vast grassy plain, with . . . . . rocks protrud- "ing from it. When exposed to the sun, these rocks assumed a tem- "perature far higher than that of the adjacent grass; over each of "them therefore rose a column of heated air, less dense than that which "surrounded it. Thus by day the sound had to pass through an "atmosphere which frequently changed its density; the partial echoes

* "On the Mathematical Theory of Sound." Phil. Trans., vol. 150.

" at the limiting surfaces of rare and dense air were incessant, and the " sound was consequently enfeebled. At night those differences of " temperature ceased to exist, and the sound-waves, travelling through " a homogeneous atmosphere, reached the ear undiminished by reflec- " tion."* Such being the effect of the surfaces of contact of masses of the same medium, where the difference of their densities is but slight, it will be at once apparent that the interposition of particles or films of a substance totally different in density and elasticity would produce the same effect in a much greater degree.

If the above be, as I believe it is, a correct explanation of the manner in which fog acts upon sound, it appears singular that the relative penetrating effect of different sounds depends quite as much upon their character as upon their relative volume or initial power. Hence it is conceivable that sounds which consist of a great number of different waves, may contain some of the undulations which are of a character not easily reflected by the particles of the obstructing medium, and which will therefore pass through that medium with little change, whilst the remainder are arrested and lost; in a manner remotely analogous to the phenomenon of the apparent change in the colour o the sun when viewed through fog, or through the aqueous vapours near the horizon at sunset.† In both cases, the change is due to the stoppage or absorption of certain rays by the interposed medium. I do not see how, except upon some such hypothesis, we can account for the penetrating power of certain sounds—notably those of the whistle and the reed-trumpet, consisting of an indefinite number of slightly different vibrations, all however forming one general wave, as the tidal wave bears upon its bosom an endless variety of minor undulations—whilst the sound of bells, the report of cannon, and even the awful crash of thunder, the sound-waves of which are of a comparatively simplex and uniform character, though the two latter are of enormous initial power, are frequently lost at short distances.‡

Obscuring media occasionally held in suspension in the atmosphere are not the sole obstacles to the free propagation of sound. It is also powerfully affected by the action of wind blowing from the observer towards the source of sound. This is usually attributed to the circumstance of the whole mass of air through which the sound is travelling being carried bodily away from the observer, so that by the time the sound reaches him it has had to travel through a greater distance, and thus has practically had its point of origin so much farther removed from him. This view of the case, however, overlooks the fact that the velocity of sound is so enormously greater than that of the swiftest

* Tyndall's Lectures on Sound, 2nd ed., 1869, p. 18–19.

† The sun under these circumstances appears of a red colour; and it may be observed, as a somewhat singular coincidence, that a blind man is said to have described the colour of red or scarlet as being suggested to him by the sound of a trumpet—one of the instruments whose sound is the most efficient in penetrating fog.

‡ In the case of guns, this has been stated to be owing to the instantaneous character of the sound produced by the explosion of gunpowder (R. Stevenson, " Bell Rock Lighthouse," p. 231); but this, although it will account for the simplicity of the sound-wave emitted, does not appear sufficient of itself fully to explain the cause of the speedy extinction of that sound by fog.

wind, that the diminution arising from this cause can be but very slight. Professor Stokes, Sec. R. S., has given an explanation of the phenomenon, in a manner at once so simple and so satisfactory, that it leaves nothing to be desired; and, as the subject is of much importance in its relation to fog-signals, I give it in his own words:—

"If we imagine the whole mass of air in the neighbourhood of the "source of disturbance divided into horizontal strata, these strata do "not all move with the same velocity. The lower strata are retarded "by friction against the earth, and by the various obstacles they meet "with; the upper by friction against the lower, and so on. Hence the "velocity increases from the ground upwards, conformably with obser- "vation. This difference of velocity disturbs the spherical form of the "sound-wave, tending to make it somewhat of the form of an ellipsoid, "the section of which by a vertical diametral plane parallel to the "direction of the wind is an ellipse meeting the ground at an obtuse "angle on the side towards which the wind is blowing, and an acute "angle on the opposite side. Now, sound tends to propagate itself in "a direction perpendicular to the sound-wave; and if a portion of the "wave is intercepted by an obstacle of large size, the space behind is "left in a sort of sound-shadow, and the only sound there heard is "what diverges from the general wave after passing the obstacle. "Hence, near the earth, in a direction contrary to the wind, the sound "continually tends to be propagated upwards, and consequently there "is a continual tendency for an observer in that direction to be left in "a sort of sound-shadow. Hence, at a sufficient distance, the sound "ought to be very much enfeebled; but near the source of disturbance "this cause has not yet had time to operate, and therefore the wind pro- "duces no sensible effect, except what arises from the augmentation in "the radius of the sound-wave, and this is too small to be perceptible."*

I have dwelt somewhat at length upon this matter, not only because the theory of Professor Stokes at once commends itself as a satisfactory solution of an otherwise perplexing question, but also because that theory enables me to propose a practical expedient for increasing the effective range of sounds required to be sent against the wind. It is as follows:—Since those sounds have a tendency to rise, and, if originally directed in a horizontal plane, are diverted upwards in a curve convex to the horizon, they ought to be in the first instance projected in a downward direction, at an angle proportioned to both the strength of the wind and the distance at which they are required to be best heard, so as to counteract the rising tendency. Sounds to be sent across the wind should be projected slightly downwards, and those to be sent down the wind should be projected in a horizontal plane. In making this suggestion, it affords me much gratification to add that Professor Stokes, to whom I have submitted it, informs me that he considers the practical inference thus drawn from his theory to be well founded.†

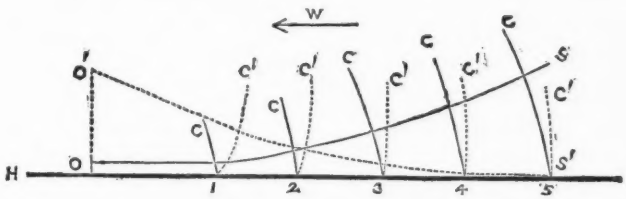
* "On the Effect of Wind on the Intensity of Sound." Report of the British Association, vol. xxvi.

† In the accompanying diagram, the full lines illustrate the case of a sound emitted near the sea-level, and the dotted lines that of one emitted at an e

From this view of the case it will be perceived that there is no necessity for seeking to place a fog-signal low down, but that on the contrary it ought to be situated at a height such as will allow its sound to be projected at the required depression and at the same time clear of any rocks or other obstructions on or near the shore; and in this clearance of impediments near at hand an elevated situation possesses another decided advantage over a low one.* Owing to the diffraction of sound, the signal will be audible at points within the distance to which the principal phonic beam is directed.

In order to guard against misapprehension arising from the idea that sound projected downwards from a height has to penetrate a greater thickness of fog† than when projected horizontally from near

and suitably depressed. Let H S′ represent the surface of the sea; O the point of origin of the sound at the low station; O′ that at the high station; 1 C, 2 C, 3 C, &c., a vertical section, parallel with the direction of the wind, of the curves of the sound-



wave from the low station, at the horizontal distances 1, 2, 3, &c.; 1 C′, 2 C′, 3 C′, &c., those from the high station (the curves in each case being exaggerated, to render them more distinct); W the direction of the wind; and S′ the point at which the signal is required to be best heard. A sound emitted from O, travelling in a line normal to the curves of its wave, will gradually rise until, at the distance 5, it will be at the point S. As no phonic ray can be sent direct to S′ from O, the space between the lines O S and H S′ will be in sound-shadow, the only sound which reaches S′ being what diverges from the general wave below the line O S, and, owing to the rising of this line, the distance between it and the sea-level becomes greater and therefore the divergent sound heard at that level becomes weaker, as the distance from O increases. A sound emitted from O′, at a suitable depression, travelling in a line normal to the curves of its own wave, gradually approaches the surface of the sea, which it reaches at the point S′, as intended. In this case also (if no phonic ray be emitted at a greater depression), the space between the lines O′ S and H S′ is left in sound-shadow, but with this important difference, that, owing to the depression of the line O′ S′, the divergent sound heard at the sea-level increases in strength as the distance from O′ increases.

* Whilst engaged lately in making a small survey on the Welsh coast, I had occasion to try in practice the principle above stated. The weather at the time was boisterous, and it was blowing very fresh. Several times when my men were to windward of me, although at no great distance, it would have been impossible to communicate vocally had I shouted point-blank at them; but by directing my voice towards the ground between us, I was able to make them hear.

† In order to simplify expression, I shall in the remaining portion of this Paper (except in quotations) employ the general term "fog" to denote any atmospheric obstruction, whether it be cloud or mist, falling snow, sleet, thick rain, or true fog; and the term "true fog" will be used when it is intended to restrict the meaning to fog in a purely meteorological sense.

the surface of the sea, it will be sufficient to point out that, if the difference of level between two stations be 150 feet, and the horizontal distance to which the sounds from each are directed be 2 miles, the difference of hypothenuse and base, or in other words the additional distance to be traversed by the sound from the upper station, amounts to only 11 inches, and, the greater the distance to which the sound is directed, the less does this difference become.

I refrain from at present entering upon the details of the application of this principle, because the considerations involved therein are of a somewhat complex nature, the full investigation of which would constitute a Paper in itself, and must be reserved for separate treatment. But it may here be added that, provided as we are with instruments suitable to the purpose, the principle is of easy application in practice.

The requirements of navigation in connection with fog-signals are as follows:—First, the signal must be distinctly audible, under the most unfavourable circumstances, at such a distance as will enable the mariner to profit by the warning it conveys. Secondly, the direction from whence it comes must be readily ascertainable. Thirdly, it should be of such a distinctive character as to indicate, not only that there is a signal station there, but also what particular station it is.

As to the first of these requirements, the most unfavourable conditions of weather are, thick fog, with a whole gale of wind on-shore, and a heavy sea running. Respecting the space required by a ship, under these circumstances, in wearing round to haul off shore, Captain Brent informs me that a large Australian clipper—which, owing to her length and sharpness of build, I presume to be the type of sailing-vessel most exacting in that respect—will require from three-quarters of a mile to a mile, allowance being made for the effect of a heavy sea upon her drift during the process. This estimate is confirmed by the opinion of merchant captains whom he consulted, who had had extensive experience in command of large Indiamen. Even our large ironclads would not require more room than above stated, since, in heavy weather or when nearing the land, they always have steam up, and Captain Brent adds that he has seen no sea towards which they will not turn. It may, therefore, be considered that, allowing a margin for safety, 2 miles is the effective range requisite in a fog-signal. In situations where there are outlying dangers beyond the signal, this range must extend 2 miles clear beyond those dangers, if not too distant—in which case it would be folly to attempt to cover them by a signal stationed on shore—and therefore in some cases the signal may be required to have an effective range of 3 miles. Admiral Sir Alexander Milne, to whom I have also applied in reference to this question, points out, what it is important to bear in mind, that in fog a prudent person would not run down to less than a mile and a half from a suspected danger, and would keep the lead going.

From the details already given respecting various fog-signals, it will be quite evident that the only instruments possessing sufficient range to fulfil the first requirement are trumpets, whistles, and perhaps

guns.* The use of a gun, however, is open to the following grave objection. A single gun cannot be continuously worked, loaded, and fired, by one man, at intervals of less than a quarter of an hour, and it has been already pointed-out that even this entails very severe labour. Now a vessel going only 8 knots passes over 2 miles in that time; and therefore, even on the assumption (which is far from being confirmed by facts) that the effective range of a gun is 2 miles, if the vessel comes within range just after the gun has fired she will be close in with the signal before it is repeated. The average chance is that she will come within range midway between the signals, in which case she will run 1 mile before the signal is repeated, and will then be within 1 mile of the station, which, as has been already shown, is too close. To meet the difficulty, two or more guns may be employed, so as to shorten the intervals of firing: but this will necessitate the employment of additional gunners and the expenditure of more stores and ammunition, increasing to an extravagant amount the heavy working cost of the signal, already nearly three times as great as that of the most expensively worked trumpet or whistle.

It may be urged, in reply, that in the great majority of cases of fog the wind is either light, or fair, or off-shore, and that to instance the requirements of a ship in such a combination of unfavourable conditions as has been described is to assume an extreme case. But it is precisely with extreme cases that we are bound to deal in this matter, and I entirely decline to consider any others.

The selection then lies between the trumpet and the whistle, and the evidence respecting the efficiency of both appears to warrant the employment of either. Where a trumpet already established has been carefully tested and found to have the requisite effective range, it may with propriety be retained until the cost of repairs, which we have seen to be a fatal objection in some cases, renders it expedient to renew the apparatus. In such an event, or where a new station is to be established, I should (excepting in a case to be mentioned under the third head) give the preference to the whistle, on account of its superior efficiency and its slightly lower working cost.

With reference to the second requirement of navigation, viz., that the direction in which the signal lies shall be readily determined, some evidence has been already adduced of the efficiency of both the trumpet and the whistle, and although it is not intended to assert that they are absolutely reliable in this respect, it is at least certain that they are superior to any other known signal. As regards the efficiency of guns, the experience already quoted of Admiral Sir Alexander Milne is distinctly in their favour, and deserves attentive consideration. But I am bound to add that this is the only direct evidence upon the subject which has come under my notice; and it may reasonably be doubted whether a momentary explosion occurring only every fifteen minutes can be so readily referred to its true bearing as a signal lasting five or ten seconds and repeated twice or thrice in every minute.

* And perhaps also syrens; but I do not include them, because we have not as yet sufficient evidence respecting their effective range.

The third requirement of navigation, that the signal shall be of such a distinctive character as at once to indicate its identity,* is one which equals if it does not even exceed in importance the distinctive character of a light. For the comparative clearness of the weather which enables a light to be seen, presupposes that a previous view of the land in the case of a coaster, or the usual observations in the case of a vessel from over-sea, may have enabled the ship's reckoning to be kept with sufficient accuracy to afford some notion as to her whereabouts. But as regards a fog-signal, the very fact of its being in operation suggests that other sources of information as to her position are not available. The distinction of lights into fixed, revolving, and flashing, is necessary to prevent confusion and uncertainty arising from their great number and frequent proximity to each other, and the same remark will apply to fog-signals. Very considerable attention is accordingly paid in America to the preservation of a distinctive character in those signals, both by variations in the intervals and duration of the sound, and by the use of different instruments at different stations.

The trumpet, the whistle, and the syren, are capable of being varied in their character to a degree which renders them in this respect the most efficient of instruments. Their long and short blasts, and long and short intervals, which can be regulated with the greatest nicety and combined in any required manner, afford the means of almost indefinitely varying the signal, and admirably adapt them also for telegraphic—or rather, telephonic—purposes. Viewed in relation to their very distinctive sounds, all three are equally valuable, and the judicious selection of one or the other for any particular station is a matter of no slight importance. It is to be borne in mind, that even if the exact number or duration of their blasts should escape observation, still, if the observer knows that the signal at a certain point is (say) a whistle, and that the signal next to it on one side is a trumpet and on the other a syren, he cannot err in the determination of his position unless he be uncertain respecting it to an extent amounting to the distance between three different stations; which is evidently a better state of things than if he knows that the same description of instrument is used at several consecutive stations, and that his only chance of identifying the signal is to be very exact in noting the duration and arrangement of its blasts and intervals.

The difficulty which appears to be experienced in obtaining a sufficiently diversified code of gun-signals even on board men-of-war, where no lack exists of either men or pieces, shows how incapable of variation must be the ordinary gun fog-signal at a station on shore. One man cannot make the signal at less than quarter-hour intervals; and to make the intervals longer as a distinction would only render the signal more defective, for the reasons already stated under the first head.

In treating of the requirements of navigation, all reference to bells has been omitted, because they occupy a peculiar position. The evidence respecting their effective range is extremely unsatisfactory; and that respecting the facility with which the direction

* The importance of this matter is pointed-out in the Report of the Royal Commission on Lighthouses, 1861, p. xi.

from whence their sound proceeds can be recognized, is confined to the case at Kingstown, already mentioned.* As regards their distinctive character for locality, that may be secured by a judicious arrangement of the intervals of their striking. But the peculiarity of their position consists in this,—that they are as yet the only fog-signals available at rock lighthouses, the present arrangement of those buildings being unsuited to the establishment and working of either a caloric or a steam engine. A whistle, placed on the summit of the lantern, would be safe from injury by the sea; but the manual working of any instrument depending for its sound upon the compression of air would entail an amount of labour requiring the services of relays of men, and is therefore out of the question. There is, however, a mighty agent constantly at work, in the rise and fall of the tide, which has already been sought to be applied to this purpose. It is the agent proposed by Mr. Humphreys for the working of his "Clamor Æstus;" and recently Signor Tommasi has proposed to apply it, in the "Flux Motor," to the driving of pumps for the compression of air. The situation of a rock lighthouse—usually far advanced seaward, and indicating either a danger to be avoided or a leading mark to be sought-for—seems especially to demand an efficient fog-signal. It is therefore of the highest importance that some scheme should be devised for supplying this demand. I have little doubt that the ingenuity of man will one day overcome the difficulties which at present beset the utilization of the vast motive power gratuitously offered by bountiful Nature for our acceptance; and, when this is accomplished, even a rock lighthouse may be found to possess an efficient fog-signal.

It would be in the highest degree satisfactory, were it possible to conclude that in the trumpet and the whistle we possess instruments entirely fulfilling the requirements of navigation. With the exception, however, of the conditions involved under the third head, such is not the case; and, notwithstanding the favourable evidence which has been adduced respecting them, all that we are as yet entitled to say is, that they are superior to any other known instrument. Much additional information remains to be acquired before we shall be in a position to pronounce either of them to be perfectly efficient and reliable.

Now the acquisition of this information may be effected in one of two ways; either by awaiting, with more or less attention and desire of being instructed, the results of investigation and experiment elsewhere; or by investigating and experimenting for ourselves. The former method will be preferred, where a small economy of trouble and expense in the first instance is the object of primary importance. But it is attended with this disadvantage to those who follow it, that they must either remain always behind the times, or else be perpetually exposed to the risk of adopting an instrument which on more extended trial in practice is found not to be a success. And, as regards expense, the cost of abandoning one instrument and taking-up others which from time to time may be elsewhere proved or supposed to be

* *Ante*, p. 647.

superior—assuming, of course, that a real interest is felt in the adoption of the most efficient—will ultimately be found greater than that of duly qualifying ourselves to form an independent judgment.

The principle of investigating and experimenting for ourselves is not only *per se* satisfactory, but also affords the readiest and surest means of obtaining the desired information. Accordingly, its importance has long been recognized, and its necessity has been more than once prominently set forth. A detailed and weighty statement of the case is contained in the memorial addressed in 1863 to the President of the Board of Trade by the British Association,* which deserves to be attentively studied; not only on account of its valuable practical suggestions, and of its containing a complete resumé of the then state of knowledge in this country respecting fog-signals; but also because it had its origin, not in any desire on the part of scientific men for mere abstract information, but in an application made to them by the Chamber of Commerce and several of the leading merchants of Belfast, and it is therefore a correct indication of the high importance attached to the subject by shrewd men of business interested in shipping and commercial pursuits.

Reference has already been made to some experiments upon bells by the engineers of the Corps des Ponts et Chaussées; and I learn from M. Reynaud that experiments upon various fog-signals, which were in progress in 1870, and were interrupted by the war, will be resumed as soon as the necessary arrangements for the purpose are completed.

In the United States, the subject has been one of constant interest to the Lighthouse Board since its organization in 1852; and, since 1866, a permanent Committee on Experiments has been established, and is presided-over by Professor Henry, Director of the Smithsonian Institution, Washington. No results of their investigations have as yet been published, but Admiral Jenkins, Naval Secretary to the Board, has obligingly promised to communicate them to me when the Committee's Report is made. With reference to those investigations, Admiral Jenkins states:—"We are aware that we have so far neglected the "the most important experiment in regard to these instruments, viz., "that of their power and effect during fogs of greater or less density. "All our experiments so far have been made in good clear weather, and "in several cases with a view to devise some sure and practicable means "by which to transmit the sound to the desired direction with the aid "of sounding-boards and other methods of reflection. We propose to "enter upon a more regular and systematic plan of experiment with "different kinds of fog-signal instruments at no distant day, the main "feature of which is designed to be that they shall be made during the "actual existence of fogs, and under the influence of different forces "and directions of the wind. We have a large number of fog-signals "in operation, and more are being set up. *The demand for these aids "to navigators has been so pressing that we could not wait to determine "which is really the best, but endeavoured to make up for that by introducing some of all the different kinds, so far as they are adapted to*

* Report of the British Association, vol. xxxii., p. 105 *et seq.*

"*special localities*."* Since the organization of the Lighthouse Board in 1852, there have been established on the coasts of the United States not less than 14 steam-whistles, 3 steam-syrens, and 16 horns and trumpets, besides lighthouse bells, auxiliary trumpets, and the bell and horn uniformly supplied to and used on board of their light-vessels. When it is remembered that within the same period—during many years of which, unexpected difficulties must have been caused by the civil war,—the Board was also occupied with the labour of entirely re-organizing the lighthouse service, and of effecting general and extensive improvements in the buildings and apparatus of the lighthouses, which previously were in a wretched condition,† it will be cordially admitted that our American kinsmen have herein set an example which is as creditable to their energy as it is worthy of imitation.

I have not heard that any special investigations and experiments have been made in the Dominion of Canada; and it is extremely probable that the similarity of the meteorological and climatic conditions of the Canadian provinces to those of the Northern States, as well as the frequent opportunities afforded by proximity and constant intercourse, of exchanging information upon the subject of fog-signals and of attentively observing their results in practice, rendered separate experiments unnecessary. The Department of Marine and Fisheries has intelligently appreciated the value of the trumpet and the steam-whistle—the latter of which, indeed, was first employed in New Brunswick—and the coast is now well supplied with those signals, additional ones being also from time to time established wherever found requisite.

Now, it may be confidently affirmed, and the assertion will be corroborated by the experience of all who are acquainted with the nature of experimental investigation, that in this country, differing as it does from America in every particular of its climate, meteorology, and local phenomena, no mere study of the results obtained from experiment there, and no amount of observation, however painstaking, of the working of the fog-signals there established—even supposing that such study and observation were diligently followed-up—can afford the same clear insight into and thorough mastery of the whole subject as would be obtained from a scientific and searching investigation, rigorous, systematic, and comprehensive, conducted on our own shores. Not only is this true in reference to the peculiar and local considerations involved, but it applies with especial force to the innumerable practical details which such an investigation must always elicit, a knowledge of which cannot be acquired at second-hand. Even the particular manner in which a result comes out frequently affords a valuable clue to something beyond; and it is incontestable that in this, as in every other department of experimental research, the multiplication of independent centres of observation powerfully assists the attainment of the desired end. Whilst, therefore, investigations conducted in this country would have a special value to ourselves, as being made under meteorological and local conditions identical with those under which their results

* Letter to the Author, 13th November 1871. The italics are my own.

† Report of the United States Lighthouse Board, 1852.

were to be applied in practice, and as affording an otherwise unattainable acquaintance with details; they would at the same time be of important general utility, by supplementing the observations of others and thus contributing to the common stock of human knowledge.

A careful and diligent research, embracing a great number of various sources of information upon the point, and in which neither time nor trouble have been spared, has failed to discover a trace of any experiments whatever having been made in this country in reference to the effective range of fog-signals. There have been a few experimental competitive trials of some instruments; but the purpose for which they were made appears to have been simply that of determining which could be heard furthest in calm and clear weather. Such a trial, if made with the view of weeding-out those which would not come up to a certain standard, in order to reduce the number to be thereafter subjected to experiment with reference to their effective range as fog-signals, would be useful in its own way. I do not at all seek to undervalue it. What I desire to point out is this:—that to regard the results obtained as being any test of the latter quality, would be a mistake. A naval officer, under instructions to report upon the efficiency of two different apparatus for lowering boats in a sea-way, and wishing to ascertain in the first instance which of them could be handled and put in operation in the shortest time, might with perfect propriety experiment upon this point in the East India Docks; but if he should regard the experiment thus made as being a test of their relative or absolute value in reference to their intended purpose—that of safety and efficiency in a rough sea—and should report accordingly, he would commit a precisely similar error.

It way be asked why, if this be the case, has the action of the United States Lighthouse Board been mentioned in terms of commendation, seeing that they also have hitherto neglected to make experiments during fogs? The reply is:—first, that their fine-weather experiments appear to relate to the best means of transmitting sounds in a given direction by means of reflectors and other appliances, and to the mere mechanical details of the instruments; and at any rate are not regarded as determining the effective range of the instruments, the necessity of special experiments for that purpose being fully recognized: and, secondly, that the sole cause which has prevented the Board from experimenting upon that matter is, that their time has hitherto been fully occupied in actually establishing, at many different points on the coast, the best available instruments of different kinds, to meet the pressing demands for fog-signals.* The two cases are totally dissimilar.

Having thus advocated the institution of inquiry and experiment, with a view to the further development of the fog-signal system in this country, it will naturally be expected that I should be prepared to state the nature and extent of the investigation recommended; and this I shall now proceed to do.

(A). The first point calling for examination is that respecting the

* *Ante*, p. 670.

relative densities of fogs, and it will be necessary to obtain some standard by which these may be determined.

In the treatise on fog-signals already quoted-from,* Mr. Cuningham suggested that an optical test should be applied to this purpose, by observations respecting the distance at which coloured poles ceased to be visible. In a subsequent paper† he states that a series of his proposed experiments was tried, under the auspices of the Commissioners of Northern Lighthouses, at certain stations on the Scottish coast. "The means supplied," he says, "were exceedingly simple, "being a pole coloured red, white, and black, in equal divisions. The "direction to the light-keeper was in fog to observe the pole (which "was to be placed horizontally), and by retiring gradually from it, to "report at what distance *in feet* each colour disappeared from the eye, "so as to establish which colour was most visible in fog." From the returns of observations at eleven stations for six months, it appears that the distances in feet at which the colours ceased to be visible, averaged as follows:—White 230, Red 251, Black 278. The maximum and minimum distances are not given in Mr. Cuningham's statement, but it is probable that they varied considerably, according to the density of the fog. The mean results are only valuable in connection with the general ratio of visibility of the three colours, and also as showing that the distances are not too great to be conveniently measured-off.

(Aa). A series of observations, based upon this method, should be made. For the purpose which I have in view, it will be sufficient to to make them at one station; and, for the sake of accuracy, it will be well to have two poles and six observers (two to each colour).

(Ab). Simultaneously with these, and in the same locality, observations will be made upon the maximum distances at which sounds can be heard. The instruments to be employed are the gun, the trumpet, and the whistle. The experiments should be tried in flat calm, and there should be as little disturbance as possible from other noises. The phonic signals will be made separately, in regular order, with prearranged uniform intervals of such duration (probably 3 or 5 minutes) as may be found most convenient. The order of sequence in which the phonic signals are made is of no importance: the gun may come first; then, after the fixed interval, the whistle; then, after the same interval, the trumpet; and then, after a double interval, the gun again, the series being repeated as many times as the duration of the fog will permit. The pole-observers will be told-off in three groups, two observers for each colour; and, at the time of sounding of each signal, they will independently note the distance at which the colours are lost. The positions of the sound-observers will be previously marked-out, at regular intervals, at distances of not more than a quarter of a mile apart, and there should be two observers at each point. Their duty will be to note, independently of each other, whether they hear each signal, and what is its character and quality. A subsequent examination of their returns will give with tolerable exactness the range of each signal.

* *Ante*, p. 647. † March 1866. Trans. Roy. Scottish Soc. of Arts, vol. vii.

(Ac). The foregoing experiments are to be accompanied by careful barometric, thermometric, and hygrometric observations, at a suitable station in the same locality, in order to establish an additional test of fog, and to afford a means of accounting for any discrepancies which may appear in the results when tabulated.

The intention of this series of observations is, to determine whether there is really any definite and constant relation between the effect of fog on the visibility of an object and the audibleness of sound. Such a relation having been, if possible, determined, its practical value will be very great. The test of vision will not only be of constant usefulness in the succeeding experiments, but it will afford a means of supplementing them by observations upon the efficiency of signals already established at different stations, and will lighten the expense to be incurred, by enabling us to take advantage of such instruments as the large bells at the Start, the South Stack, and on the Irish coast, for the purpose of experiments. Without such a standard measure for comparison, these could not be made available for the general series, since it would be impossible to compare results obtained from them with those obtained from that series. The expense of fitting-up even one such bell for the general series would be considerable, whereas three or more would be rendered available by applying the standard test to the fogs in which they were tried. I therefore consider this preliminary investigation to be both important and necessary.

(B). The second series of experiments relates to the determination of the question, whether sounds to be sent against the wind should be originated near the level of the sea, as is usually considered desirable; or at an elevation, with a suitable depression of the principal phonic ray, in accordance with what has been above proposed.* This series, having no relation to the question of fog, will be made in clear weather, a mode of proceeding which will save much time, as regards both the opportunities of making the experiments and the facility with which distances can be determined. The experiments will be made during the strongest available winds, and as directly to windward as possible. The force of the wind will be ascertained simultaneously by the anemometer and by the usual estimation according to the Beaufort scale. The double mode of observation is not intended to determine the relation between the actual pressure of the wind and its estimated force, a question upon which there is considerable difference of opinion. Colonel Sir H. James, R.E., has given a table of pressures which he considers equivalent to the numbers on the Beaufort scale;† and a popular method of approximation to the pressure in lbs. per square foot consists in halving the Beaufort number and squaring the quotient. I am indebted to the kindness of Mr. Scott, F.R.S., Director of the Meteorological Office, for pointing out that the conversion of the Beaufort numbers into equivalent pressures is not as yet positively determinable by any fixed rule, a fact which has been verified by numerous comparisons of estimated force with corresponding anemo-

* *Ante*, p. 664.

† "Instructions for taking Meteorological Observations," p. 31.

metrical observations. But both methods of notation will be adopted in the experiments now under consideration, in order that nothing may be omitted which may be useful in checking and comparing the results obtained.

(Ba). For the signals in this series it will be sufficient to employ the gun, the trumpet, and the whistle. Two of each will be required; one placed 15 or 20 feet above the sea-level, and the other at an elevation of 100 or 150 feet. Bearing in mind the object of this series, which is to determine the most efficient method of overcoming the resistance offered by the wind to sound generally, as well as to the sound of certain particular types of instrument, it will be apparent that nothing strictly in the sense of a competitive trial between the different instruments is intended. The arrangement of the signals in groups, therefore, is made merely in order that advantage may be taken of the occurrence of a suitable wind, and the position and distance of the observer, to obtain a test of them all. The order of sequence of the different instruments is not in itself important, but, when once commenced, it must be adhered-to. The following appears to be the arrangement best calculated to attain the desired end. Lower gun. Interval 1 minute. Upper gun, horizontal. Interval 4 minutes. Lower gun. Interval 1 minute. Upper gun, first depression.* Interval 4 minutes. Lower gun. Interval 1 minute. Upper gun, second depression. Interval 4 minutes. Lower whistle, blast 10 seconds. Interval 50 seconds. Upper whistle, blast 10 seconds. Interval 1 minute 50 seconds. Lower whistle, blast 5 seconds. Interval 55 seconds. Upper whistle, blast 5 seconds. Interval 2 minutes 55 seconds. Lower trumpet, blast 10 seconds. Interval 50 seconds. Upper trumpet, horizontal, blast 10 seconds. Interval 1 minute 50 seconds. Lower trumpet, blast 10 seconds. Interval 50 seconds. Upper trumpet, first depression, blast 10 seconds. Interval 1 minute 50 seconds. Lower trumpet, blast 10 seconds. Interval 50 seconds. Upper trumpet, second depression, blast 10 seconds. (End of group.) The interval between the groups will depend upon whether the observer is able to shift his position (as in the case of his being on board a steamer), in which case sufficient time must be allowed for the move, and the group will be repeated upon the interchange of a pre-arranged signal. If observers are stationed at various points previously selected, the interval between the groups need not exceed 10 minutes. The question of the position of the observers will be considered hereafter.

(Ba *a*). A modification of this series may be advantageously made if the whistles are furnished with sound-concentrators or reflectors. In this case the principal phonic ray of the upper whistle will be sent first horizontally, and then at the two depressions, as arranged for the gun and the trumpet. It will be desirable, however, to try the naked whistle in each group, and this will require a special interval to allow

* The actual amount of depression to be given to the signals will depend upon the force of the wind at the time, and will be noted by the person in charge of the signal. The first and second depressions will be the minimum and maximum limits required, as ascertained by calculation.

time for the removal and re-fixing of the reflector. This interval can be filled-up with an intermediate group of the gun and trumpet signals. It is unnecessary here to enumerate all the details of these groupings, the character of the series having been sufficiently indicated. It is, however, to be borne in mind, that no time is to be left unemployed if it can be turned to account, since the occurrence of a strong and favourable wind is an opportunity not to be wasted.

(Ba *b*). The duty of the observer or observers will be, to note the effect of each signal of the series, comparing the relative strength of those made by the same description of instrument. The sound of the lower gun, for example, is to be described according to its strength and general character, and that of the upper gun is to be compared with it and described accordingly. The whistle and trumpet will each be entered in a similar manner. It cannot be too carefully remembered that this series is intended as a competitive trial, not between the gun, trumpet, and whistle, but between the instruments of each description at the upper and lower stations, and also (if the whistles are furnished with reflectors) between the lower whistle when so furnished and when naked, and between the upper one when so furnished and when naked.

(Bb). Another duty of the observers will be, to test the precision with which the local source and direction of the signals can be determined, and the method of doing so cannot be better described than in Mr. Alexander's words. "Uniformly the fainter the sound, the "more vague is its presumed direction, while in proportion as its "intensity increases, it can be ascribed within small and smaller "limits to a particular quarter. In applying this test, the best mode "I could devise was to close my eyes just before the moment when "the sound was expected, to turn round two or three times in order "to confuse and lose as much as possible any conscious orientation, "and then when I heard the sound to point, still with eyes closed, in "the direction along which it seemed to reach me. As the station "itself was visible from where I stood, the deviation of the supposed "from the true line was readily observable."*

This series will be repeated whenever an opportunity occurs, until a definite conclusion is arrived-at. The value of the result so obtained will be fully appreciated in the concluding series of experiments, which is intended to determine the effective range of the various instruments. As this is a point which will be hereinafter referred-to, I shall at present merely observe that this series is essentially necessary.

(C). The third series of experiments relates to the trial of new instruments and appliances, and of various modifications of existing ones. It is very far from my intention to advocate, and I desire to avoid even the appearance of advocating, any investigation of a purely speculative character, or having for its object the originating of new inventions—a thing which in this country is regarded with perhaps not altogether unreasonable distrust. There are, however, some instruments not hitherto employed as fog-signals, which appear to possess sound and power suitable to the purpose. There are also some

* "Report on Fog-signals," *ubi sup.*, p. 102–103.

questions connected with the distinctive character and quality of sound in relation to the penetration of fog, which ought not to be overlooked in a practical inquiry. And there are certain modifications and details of existing instruments, directly and intimately connected with the efficiency of those instruments, and which must therefore be examined. The arrangements necessarily made for the principal line of the present investigation afford facilities for the prosecution of inquiry respecting these matters, of which it will be well to take advantage.

(Ca). Under the first subdivision are included organ-pipes; and since, as is well known, the largest wooden pipe of an organ can easily be sounded with the breath, it is worth trying what effect would be produced by a powerful blast of air, and also (which is to some extent connected with the second subdivision) whether a battery of such pipes could be arranged which should produce a very compound and penetrating sound. If the result be sufficiently favourable, they will be noted for experiment under series (D). This subdivision also includes such instruments as Humphrey's percussive whistle and Wigham's gas-gun. The latter has been experimentally tried by the Commissioners of Irish Lights, and is favourably mentioned by Captain Hawes, who says:—"Instead of gunpowder guns we have been trying an "invention of Mr. Wigham's, by which gas is used for charging and "firing heavy guns. The advantages he claims for his system are, "that, while the sound was as great as necessary for fog-signalling "purposes, the flash is much brighter than that proceeding from an "ordinary cannon, which is a consideration of much moment."* This instrument, if found to possess sufficient effective range, would be a valuable addition to fog-signals, since it would probably be free from the objections already stated in reference to guns on the score of expense and of the difficulty of quick repetition. It will therefore be fully tested, and its effective range ascertained as hereinafter described. The percussive blast proposed by Mr. Humphreys† will also receive attention, his own experiments having proved that it produces a very distinctive and characteristic sound from a whistle.

(Cb). The second subdivision, relating to the special penetrating power of certain qualities of sound, although partially covered by trials of instruments in the other series of the general inquiry, is of sufficient importance to require more particular investigation. It has already‡ been seen to be probable that there may be an analogy between sound and light in the effect of fog upon them, and this probability will be strengthened if series (A) should establish a definite relation between the stifling or deadening of the one and the obscuration of the other. The clue thus obtained is to be followed-up, by experimenting upon the effect of combinations of sounds in a single phonic ray, and observing which of the sound-waves has the greatest penetrative power. It is extremely probable that this will be found to vary in a tolerably well-defined manner with the different descriptions of fog. Should this prove to be the case, a further clue will be afforded for investigation, since certain kinds of fog have a definite modifying effect upon trans-

* Report to Commissioners of Irish Lights, 10th April 1872.

† *Ante*, p. 658. ‡ *Ante*, p. 663.

mitted light; and the result may be to indicate a practical means of varying and combining certain qualities of tone according to the character of the fog to be penetrated. The investigations under this subdivision will have also a practical bearing upon the use of the syren, as already indicated.*

(Cc). The third subdivision is intended to relieve series (D) by preliminary experiments upon modifications and details of various instruments; a service the utility of which will be hereafter apparent.

(Cc *a*). Mr. Alexander's experiments upon the most efficient pressures of steam for whistles have been already mentioned,† and it will be proper to devote some care to the determination of this matter in its relation to the size of the whistle. The important practical bearing of the question is forcibly illustrated in the case of the steam-whistle about to be established at Cape Race, N.F. It was at first intended to use at that station a 12-inch whistle. I find, however, on reference to the papers at the Board of Trade, that early in the present year it was recommended by the engineering advisers of the Colonial Government that a 10-inch whistle should be substituted, on the ground that experience had proved that the latter gave a more powerful blast with the pressure intended to be used; and the alteration thus proposed has been sanctioned and will be carried-out. In connection with this point, it may be mentioned that Mr. Bailey informs me that his "steam-roarer" is, by adjustment, suitable for either high or low pressures. Its capability in this respect will be investigated. It is also a question of interest, and will form a proper subject for experiment, whether the effect of a given quantity of steam can be most advantageously applied to one large whistle or to two or more smaller ones. The most suitable and efficient pressures for trumpets and syrens will also be tried and ascertained.

(Cc *b*). The uniformity of sound of Holmes's trumpet over a horizontal arc of 90°, a property of great value in certain cases; and Brown's syren-trumpet above mentioned, which comes to us recommended by the opinion of Professor Henry; will also be carefully tested.

(Cc *c*). Reflectors and sound-concentrators are included in this subdivision. Among the instruments to be experimented-upon are Cowper's elongated reflector and Stevenson's holophone. From both of these, good service may be anticipated, provided that the effluent steam can be prevented from smothering the sound. Whilst upon this subject, it may be observed that although parabolic reflectors are frequently recommended, and in many cases may doubtless be applied with considerable practical advantage, yet it should not be lost sight of that the principle of the reinforcement of sound by resonance, so admirably illustrated by Tyndall,‡ is of very great importance, and deserves investigation with reference to its applicability to the purposes of fog-signalling.

(Cd). A fourth subdivision will consist of anemometrical observations, having for their object the determination of the different velocities of the same wind at different heights, when blowing over a

* *Ante*, p. 660. † *Ante*, p. 660.

‡ Lectures on Sound, *ubi sup.*, p. 171–177.

level surface. These observations will supplement our at present imperfect acquaintance with the subject, and have a direct practical bearing upon the experiments (Ba) and (Ba a) relating to the projection of phonic signals to windward.

The foregoing four subdivisions are, for convenience of reference, classed as a series, although in point of fact they are not to be strictly regarded as such, but may be conveniently made on various occasions as opportunity offers; and the fourth subdivision (Cd) will properly precede series (B), in order that as much advantage as possible may be taken of the results for practical use in that series.

(D). The first series (A) having afforded the means of measuring the density of a fog, and the second (B) having determined the best method of employing the sound of three principal and typical instruments when sent to windward, the way is now cleared for the fourth series of experiments, the object of which is to determine the effective range of the instruments employed as fog-signals, viz., guns, trumpets, whistles, syrens, bells, and gongs.

(Da). The course to be pursued in the carrying-out of this series is comparatively simple, but the series will extend over a considerable period of time, in order that opportunity may be afforded for the testing of all the instruments in the densest fogs with the heaviest winds—in fact under the most trying and adverse conditions. The density of the fog, the force of the wind, the amount of sea-disturbance, and the barometric and other meteorological memoranda, are to be noted at the signal-station or other observatory; and the amount of local noise is to be noted at the observer's station. If the latter be situated on land, or at a fixed point, some means must be arranged for producing as nearly as possible the same amount of local noise as would accompany a paddle-steamer under full way in a heavy sea—a problem the solution of which, although indispensably necessary, is not difficult; and, as it will afford an interesting exercise of inventive ingenuity to others, I refrain from at present pointing-out the means by which it may be effected.

The tests for each description of instrument will be kept perfectly distinct, experimenting thoroughly on one at a time; and it is to be steadily borne in mind that these tests are absolute, not relative, nor in any way competitive as between different instruments. All the instruments (excepting gongs) will be tested low down as well as high up; because there are many localities requiring the establishment of fog-signals but not admitting of the signals being placed in any but a low situation, and it is therefore indispensably necessary to determine the effective range of an instrument so placed.

The duty of the observer will be, to note the amount of local noise, and the audibility and character of the sound of the signal; and, if he be at a point whose distance is not already determined, he will note his distance from the signal by cross-bearings or other suitable means.

The observations will be repeated until the maximum distance at which the signal can be heard is ascertained. If the conditions of wind and fog are also at their maximum of obstruction, the effective range of the signal is *ipso facto* determined; and, after this has been

conclusively settled by a second trial, the third repetition of the experiment (which is desirable as a check upon the former ones) will be deferred until a similar crucial test—the opportunities for which are necessarily unfrequent—has been applied to the other instruments.

It is here not unimportant to point-out the relation which the previous series of experiments bear to this one, and the value, in connection herewith, of the results which they aim at establishing. The concurrence of the densest fogs with the greatest force of wind, although not so rare as is generally believed, is yet not so frequent as to justify the use of those opportunities of determining the effective range of fog-signals, for any experiments which can be conducted under conditions of more frequent occurrence. The value of the standard test of density (A) in affording facilities of experimenting upon instruments already established at different stations, has been pointed-out. Its use in relation to the present series is this:—that it affords the means of ascertaining whether any particular fog is denser than others which have been experimented-upon—a thing of the utmost importance when it is remembered that the object of this series is to determine effective range. The experiments (B) upon the best method of projecting sounds to windward, will allow of the trial of instruments placed and worked in the most suitable manner, and will also indicate the preference to be given to certain instruments for certain situations. For example—to assume a case—it may be found that the effective range of the whistle is sufficient whether it be situated low down or high up, owing to the special power of the instrument, but that the trumpet only attains a 3-mile range when situated at a height. In this case the use of the trumpet for 3-mile ranges would be at once limited to places where it could be so placed, while the whistle would be suitable for any situation; and the information thus obtained would be of great value in the tests for effective range, by saving the unnecessary trial of the trumpet at a low level. Again, the preliminary experiments in subdivision (Cc) will settle many questions relating to the pressures best proportioned to certain dimensions of instruments, the most economical application of those pressures, the best methods of reinforcing or directing sounds, together with other matters, the trial of which in the present series would involve the loss or misuse of valuable opportunities required for experiments which can only be made on special occasions of dense fog and high wind combined.

(Da *a*). The guns to be tried are 18-pounders, one of iron and one of brass, with a charge of 3 lbs. of powder. This calibre and charge, being what is adopted in practice on our coasts, is the most proper to test. If, however, the results obtained show that the effective range of these guns is less than 3 miles, but at the same time afford indications warranting the expectation that an increase in the size and charge would produce the required effect, a 24-pounder with a charge of 5 lbs. of powder, as recommended by Sir Alexander Milne, should be tried. It must however be remembered, that all that has been previously remarked * in reference to the difficulty of working an 18-pounder with

* *Ante*, pp. 649, 667, 668.

the staff at present assigned to gun-stations, will apply with additional force to a heavier gun, and that the working cost of the signal will be increased by the use of a heavier charge of powder.

Should the preliminary trials of Wigham's gas-gun (Ca) be satisfactory, its effective range will be thoroughly tested in this series.

(Da *b*). The trumpets to be tried are Daboll's and Holmes's, to which may be added any others that have satisfactorily passed through the trials in series (C). Both the second and third order Daboll's trumpet will be tested, since one may be found effective at one range and the other at another.

(Da *c*). Whistles will be tested naked, as well as in combination with the most efficient sound-concentrators, the employment of the latter being probably not suited to every situation.

(Da *d*). Syrens will be similarly tested; and, if the experiments in subdivisions (Cb) and (Cc *a*) warrant it, they will be tried in combination with each other and with the whistle. Brown's syren-trumpet, if found satisfactory in subdivision (Cc *b*), will also be tested for effective range.

(Da *e*). Experience does not favour the belief that the effective range of bells is great. Nevertheless, whether great or small, it must be definitely ascertained. These instruments are already in use at so many stations, that experiments upon their range will be most conveniently made at some of the stations which offer peculiar advantages by reason of their admitting of the previous ascertainment of the distances at which observers can be placed. And, as bells are employed chiefly at rock lighthouses, and are therefore nearly all subject to uniform conditions of weight and elevation, there is a special propriety in experimenting upon them *in situ*.

(Da *f*). Gongs will be tested either from a light-vessel (the situation of many of which is suitable to the purpose) or from a similar elevation elsewhere. They will be sounded both by striking and by friction, and these again will be applied both continuously and at intervals, until the greatest effective range is obtained.

(Db). The facility with which the local source and direction of each signal can be determined, will be also a matter for experiment in this series, as well as in series (B).

The result of this series of experiments will be to arrange the fog-signals in groups according to their effective ranges, which will determine the suitability of the instruments for different purposes and situations. Some (it is hoped) will be found to possess the ranges requisite for great sea-signals or danger-signals; others will answer for minor signals, such as are suited to points which cannot be reached by a vessel without previous warning of her whereabouts from a sea-signal, or for channels and harbours. From the various instruments composing each group, it will easily be possible to choose those which are most effective or economical, or whose capability of conveying distinctive indications renders them peculiarly suited for alternation with others on a long coast-line. In fact this series will afford opportunities for a discriminating selection and application of instruments for fog-signals, such as never before has been possible.

(E). The subject of the position of observers has been more than once mentioned, and requires consideration. Theoretically, of course, the best situation for the observer is on board a steamer, which not only will enable him to shift his distance and bearing as required, but also will furnish the requisite amount of local noise. Some of the observations can without difficulty be made in such a situation, provided that the steamer is sufficiently powerful and sea-worthy to face a gale of wind; and probably the experiments of series (B) will be most advantageously observed in this manner. But it is not so certain that the observations to be made during fogs, and especially those of series (D), can be so conducted; whilst it is quite clear that those of series (A) must be made from fixed points. My own preference is for fixed points for series (A), (C), and (D), and a steamer for series (B). Fixed points can be selected, their distance and bearing ascertained, and any other necessary arrangements made, at leisure, before the experiments begin. Whether one method, or the other, or a combination of both, be adopted, the locality in which the experiments are to be carried-out must be selected accordingly. It may be here remarked, however, that the experiments in series (A) need not necessarily be made at the same place as the others. All that is requisite for that series is a sufficient extent of level ground, or of smooth and shallow water, with no hills round about to produce echoes, in some situation where there is very little disturbance from other noises, and plenty of fog. Snow, sleet, and thick rain, are phenomena not sufficiently rare in this country to require special care in the selection of a site, as it is not likely that any spot to be chosen will be unsuitable by reason of their too long absence.

(F). With regard to the person to whom the conduct of the investigation should be entrusted, I am decidedly of opinion that an officer in Her Majesty's Navy would be the most suitable. It is also from the Navy that I would recommend the selection of men for the work, their employment upon it being made the reward of intelligence and good conduct; a distinction which, with the addition of a small sum to their pay, would create an active competition for the service. For special scientific advice, recourse should be had to some person appointed by the Government department under whose auspices the investigation is made, and the President of the Royal Society might be invited to recommend some one for the appointment.

Such, then, is the general scope and plan of the investigation recommended. It will be observed that I propose to deal as much as possible with existing instruments, already applied to the purpose of fog-signals, or capable of being so; and that I have avoided any experiments tending to deprive the proposed investigation of that practical character which it is desirable to maintain. Nevertheless, if any invention of great *primâ facie* merit appeared, it ought to have a trial, it being obviously for the benefit of the inquiry that the most efficient instruments should be examined and tested.

The whole of the experiments proposed have a definite object, which is fully stated in each case. If notwithstanding, it should be objected

that they are not of a practical tendency, it will be necessary to inquire whether the information in each case aimed-at is or is not desirable? If it be admitted that it is—and this will hardly be denied—the question must then be asked, whether we are, at present, definitely and certainly in possession of a single one of the facts sought to be elicited? Is there any person who will undertake to affirm that we know in what respect, and to what extent, one fog differs from another in obstructing the transmission of sound? That there positively is no better way of driving a signal against the wind than by going on indefinitely increasing the power of the instruments now in use? That we are already in possession of the best possible instruments, or have any definite knowledge as to which really is the best instrument? That we even know (say to within a mile or two) at what distance our present fog-signals can be heard to windward in the heaviest thick and stormy weather? That, in short, our position, as a maritime nation possessed of the most wide-spread commerce and the largest mercantile marine in the world, is at the present moment, with respect to fog-signals, so thoroughly satisfactory, that an investigation such as now recommended is superfluous, and that money expended thereon would be money wasted?

It is not intended to assert that the proposed experiments are perfect in all their details. Modifications and improvements may doubtless suggest themselves. But it may fairly be maintained that the general principle and outline indicated are correct; and that such an investigation, if carried-out as intended, will place us in possession of a vast amount of practical and valuable information which we ought to have, of which we are at present destitute, and which without such an inquiry we cannot hope to obtain.

Before concluding, I have a pleasing duty to perform, in expressing my obligations to the Admiralty, the Board of Trade, the Commissioners of Irish Lights, and the lighthouse authorities of Canada and the United States, for valuable information derived from their records, and for the ready courtesy with which that information has been placed at my disposal.

Finally, I would bespeak the indulgence of naval men for any technical errors into which I may have fallen in reference to matters appertaining specially to the nautical profession. Of those matters it is impossible to treat with the clearness and accuracy of a sailor. But I venture to hope that such errors, if they exist, will be viewed with the leniency due to a landsman who has been obliged to travel somewhat out of his own element in the earnest endeavour to promote knowledge upon a subject of great importance, affecting not alone the maritime service, but to a large extent also the interests of civilization and the welfare of mankind.

Evening Meeting.

Monday, May 20th, 1872.

ADMIRAL THE RIGHT HON. THE EARL OF LAUDERDALE, K.C.B., &c., in the Chair.

NAMES OF MEMBERS who joined the Institution between the 16th and 20th May, 1872.

LIFE.

Dunn, R. G., Captain 9th Regiment.

ANNUAL.

Burn, David B., Lieutenant 75th Regiment.
Tipper, H. Roe, Captain 6th Tower Hamlets Rifle Volunteers.
Leighton, Frederick, Major 38th Middlesex Rifle Volunteers.

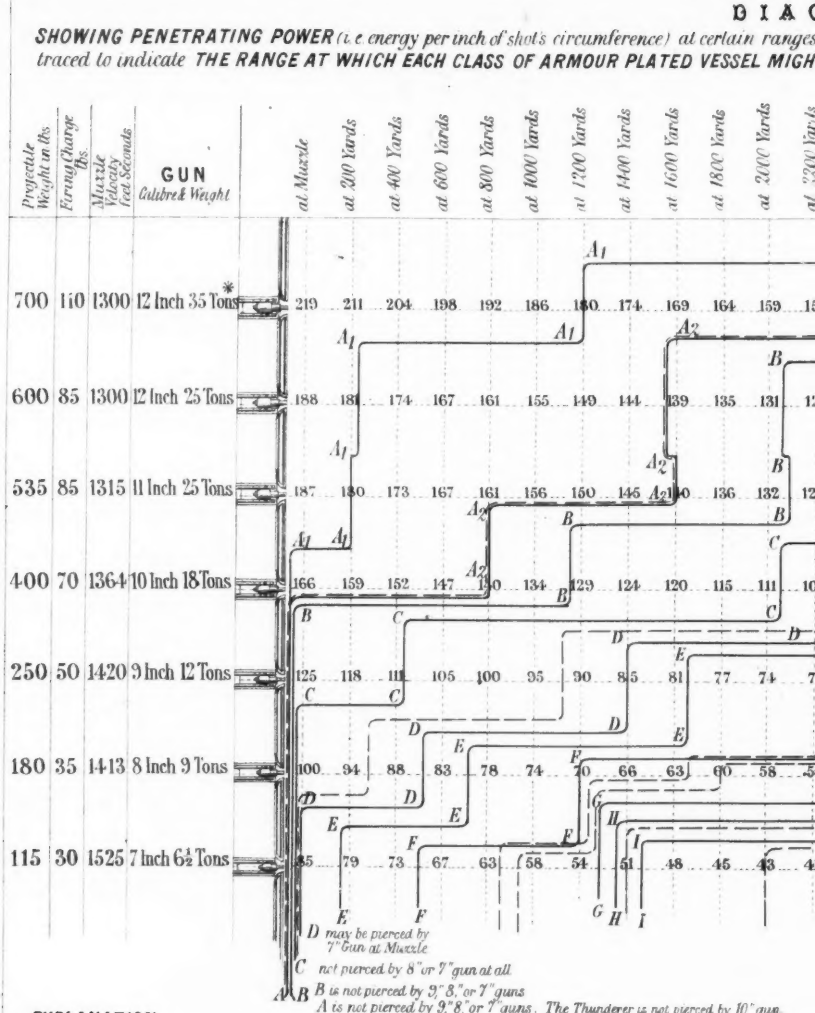
FIRING AT ARMOUR-CLADS REDUCED TO SYSTEM.

By Captain C. ORDE BROWNE, late R.A.

I TRUST that the title of my paper to-night may not seem to imply that I come forward prepared to suggest a complete system on which all firing at armour-clad vessels might be conducted, much less to endeavour to lay down the law on such a subject. While holding an appointment in the Royal Arsenal, it was my duty to describe the construction of the various projectiles adopted for the service, and I naturally endeavoured to add a few directions as to their use. I conceive that it is in no way invading the province either of Naval Officers or constructors, but the obvious duty of an artilleryman, to endeavour to arrive at the best method of using his guns against armour. He would in fact be hardly treating naval science with due respect, if he did not learn how to give an iron-clad vessel a reception suited to her character. Clearly, however, he should endeavour to obtain the opinions of those who have a professional knowledge of naval matters. Thus, while learning much from the numerous Officers of my own corps who came to the Royal Arsenal, I especially tried to profit by the visits of Gunnery Instructors of the Royal Navy and Royal Marine Artillery, as well as of French, Russian, Danish, and American Naval Officers. I only profess to have studied the question from an artillery point of view, and my aim to-night is to read a short paper leading up to a discussion in which valuable opinions may be

DIAG

SHOWING PENETRATING POWER (i.e. energy per inch of shot's circumference) at certain ranges traced to indicate **THE RANGE AT WHICH EACH CLASS OF ARMOUR PLATED VESSEL MIGH**



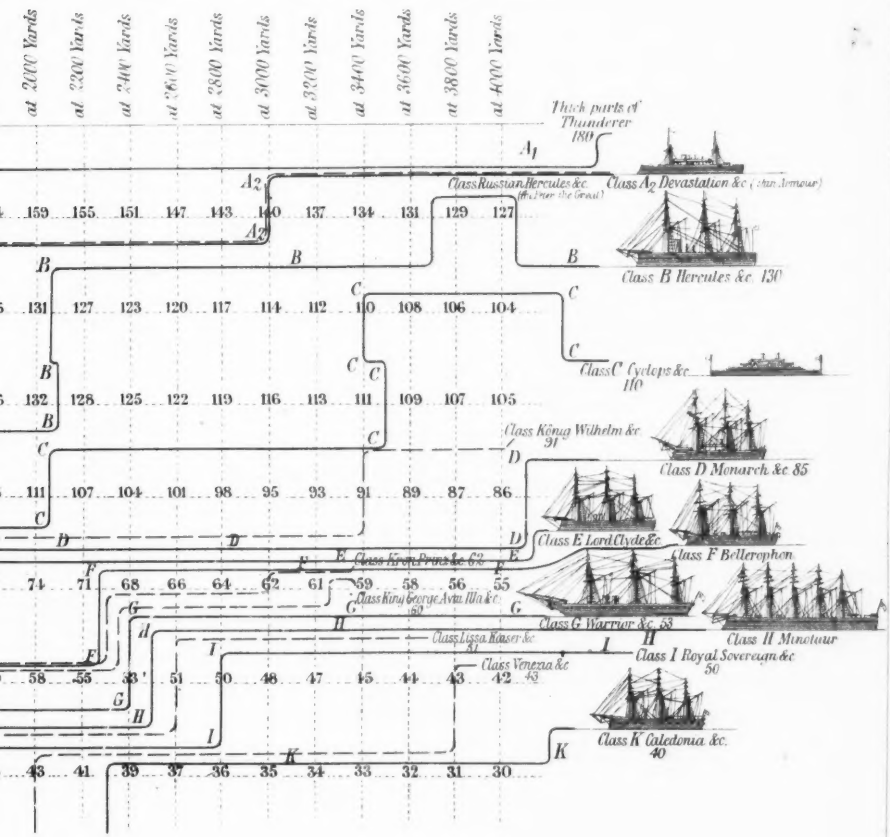
EXPLANATION.

The guns being shewn in plan, the dotted lines across their front indicate intervals of 200 Yards indicating the penetrating power at each 200 yards Thus, if the "figure" required to pierce any ship's armour b gun, is found by drawing lines through this "figure" or number wherever it occurs. Thus, if 85 foot tons per inch

** The penetrating "figures" for the 12 inch gun of 35 Tons (the so-called "Woolwich Infant") have not yet feet at the muzzle, with a charge of 110 lbs. The figures of the other guns are taken from Capt.n Noble's table in of Armour, &c. (except Class C) have been taken from Mr. Reed's work "Our Ironclad Ships." The piercing "figure" o been well established by repeated firing at Targets at Shoeburyness. In others, where no actual representative targ the armour in question. Even slight variations in conditions, however, may produce unexpected results, hence the d*

DIAGRAM

ain ranges OF PROJECTILES FIRED FROM THE SERVICE HEAVY MUZZLE LOADING GUNS, also lines SEL MIGHT PROBABLY BE PIERCED by direct fire from each gun



NOTE— *Foreign Ships are shewn thus* — — — — —

10" gun.

of 200 Yards along the range, numbered from the guns' muzzles up to 4000 yards. Opposite to each is registered the figure 's armour be known, the line or "trace" indicating at what range her armour might be pierced by the direct fire of each ons per inch circumference will pierce the "Monarch," her trace must be drawn across the range of each gun at the figure 85. have not yet been actually determined, but are here estimated by Professor Bashforth's rule, assuming a velocity of 1300 ble's table in the Extracts of the proceedings of the Department of the Director of Artillery. The Ships with their thickness ng "figure" of each class must not be taken for more than a probability. In some cases (such as that of the Warrior) it has entative target has been tested, it has been deduced from the results obtained by firing at the structures most nearly resembling , hence the diagram must only be looked upon as giving a general idea.

J. Jobbins

elicited on the subject before us, believing that the time has come when it is possible to bring the firing at armour-plated ships to a more distinct system than has yet been done.

The large diagram before you (Pl. xxii), and the greater part of the matter in connection with it, was prepared by me for the concluding article of a series on "armour-piercing projectiles" for the *Engineer*, but the Editor kindly consented to the paper being brought forward here, and to keep back the publication of it till as nearly as possible the same date; further, he has sent us impressions of the diagram struck off to facilitate discussion.*

The large diagram before you furnishes a sort of picture of the state of armour and guns which the mind can readily grasp. I have no delicacy in saying this much for it, because very little indeed of it is my own. The mass of the "piercing figures" are copied from a table worked out by Captain W. H. Noble; the idea of connecting the "piercing figures" by lines so as to trace the limit to which vessels might advance, I have taken from Captain Ford, R.A.; a great part of the figures and facts concerning the vessels, I have, with Mr. Reed's permission, taken from his work "Our Iron-clad Ships;" the method of calculating the "piercing figure" of the 35-ton gun I owe to Professor Bashforth, who has also kindly checked the calculations I had made on his system. All I can claim as my own is the particular form into which the table is brought, and the working up of the information on which I have based most of the zigzag lines; and even in this I commenced on Captain Ford's researches, his professional duties making it impossible for him to pursue the subject further at present. Even now, I am far from satisfied with some of the zigzag lines, and am prepared to alter them on sufficient cause being shown to justify me in doing so.

You will observe that this diagram (though it should not be mistaken for a plan) is given in the form of a sort of distorted plan of a battery, containing one of each of our large muzzle-loading guns. A dotted line runs from the muzzle of each gun along an imaginary range, intersected by cross lines at distances representing intervals of 200 yards, commencing at the muzzle of the gun and terminating at 4,000 yards. At each intersection is registered the penetrating power, or what we may call the "piercing figure," of each gun at that range.

One word on the "piercing figure" of a ship's armour. I have generally considered the ship pierced when any portion of a projectile gets through the skin, so that it could be seen from the back of the target. This appears to be where the line is generally drawn, and when this takes place, it must be supposed that water can enter. This tells very heavily against the wood-built ships, in which by the way as there is *no skin*, the condition of *water entering* is taken. Mr. Reed intimates that on this principle many of these ships cannot be held practically to have more than 8 or 10 inches of real backing, the timbers in rear not being water-tight, hence the low estimate of some of their figures. It may be objected that, if not near the water-line, a

* The Institution is indebted to the proprietors of the "Engineer," for permission to give a copy of the plate referred to.—ED.

penetration in this sense need not be at all a serious matter. This is quite true, but unless the line be drawn here it is very difficult to know where to take it, because a vessel might fight after shot had passed clean through her, and since a wooden ship might do the same, it is clear that, though all protection of the armour has not yet ceased, it has become a matter of degree, and in fact the vessel has passed from the condition of *security* into one of total *uncertainty*.

The penetrating power is assumed to be the energy per inch circumference of the projectile, expressed in foot tons, on the system carried out for the department of the Director of Artillery, as I have said, by Captain W. H. Noble. In order to register on this diagram the limit to which any ship may advance, without being liable to have her armour completely pierced by a single blow, it is only necessary to know her "piercing figure," in other words, the blow in foot tons per inch circumference of shot which will pierce her armour.

A list of the ironclads in the service (including many not yet completed) is appended, divided into classes according to the thickness of their armour (see Appendix); this list being in fact the one drawn up by Mr. Reed, with a few additions. The figures of ships which are selected as typical specimens of each class are partly taken from Mr. Reed's work and partly from photographs. I think they would add much to the value of the table for use on actual service by men unacquainted with the appearance of vessels.

The "piercing figure" of any class of ship being gathered from the results of experiments at Shoeburyness and elsewhere, as far as possible, it is only necessary to draw a cross line on the range line of each gun through such figure where it actually occurs, and, failing this, through the place where it would be registered if it were written in, and then join these cross lines by longitudinal ones, so as to form a continuous zigzag, showing at a glance the distance at which the class of vessel in question would become liable to be completely penetrated by each gun. This has been carried out on the table for each class as far as it could be done. The piercing figure is in some cases taken from the actual results obtained by firing at representative targets, and in others arrived at by inference, being deduced from a comparison of such experiments as seemed most nearly to the point.

It may be seen that the power of the 35-ton gun decreases faster than that of the other 12-inch gun, which throws a shorter and lighter projectile. This is clearly incorrect, but the extent of the error caused by the inconsistency is not serious. It arises from the fact that Professor Bashforth's system, on which the figures for the 35-ton gun are calculated, give results differing slightly from those worked out by Captain Noble.

Speaking generally, the zigzag lines shown on the table being obtained by some definite process which admits of explanation, contradictory statements ought to be supported by such facts as will outbalance those on which the table is based. In certain cases it is quite probable that this may be done. Some lines, it is true, such as that of the "Warrior," are established by trials, which the most voracious inquirer will find repeated to his heart's content in the records of the

Ordnance Select Committee and of the department of the Director of Artillery. Others, on the other hand, can hardly be said to be founded on more than inference, and inference in such matters, unless margins be allowed, is at times little better than guess work. I will endeavour to give an idea of the amount of dependence that may be placed on the table by taking up the case of one or two of the unsatisfactory lines.

"Devastation," "Glatton," and "Thunderer" Trace.

I will commence with Class A, which is given as a double line, A_1 running through the figure 180, and A_2 through 140. The latter represents the armour given on the table as that originally designed for the "Devastation," "Glatton," and "Thunderer," and carried out to a great extent, I believe, in the two former vessels.

In certain Swedish experiments in 1869, a target with front plates of a thickness of 12 inches, but with weaker back support, and constructed on a weaker principle than the kind in question, was completely penetrated with a "piercing figure" of 100·1. In July, 1871, a target at Shoeburyness (No. 33), consisting of 13 inches of iron, 12 inches of teak, and 1½ inches of skin, was completely and apparently easily penetrated by a "piercing figure" of 152·7. The only smaller registered blow on this target was one of 103·9, which of course failed to pierce, but which penetrated to a greater depth than might have been expected. The iron and wood were arranged in the following order:—8-inch plate, 6 inches teak, 5-inch plate, 6 inches teak, 1½ inches skin. The shot referred to penetrated to a depth of 18·2 inches; it therefore had in front of it ·8 inches of plate, 6 inches teak, and 1½ inches of skin. Now the "Warrior" backing, consisting of 18 inches of teak, and ⅝ths inches of skin, requires a force of 33 to pierce it; suppose we allow 36 for the work left undone by the shot in question, we should arrive at a "penetrating figure" of 139·9 for No. 33 target. Had the same shot penetrated through the same amount of iron and teak in our "Glatton" or thinner "Devastation" plate, viz., 12 inches of plate and 6 inches of teak, it would only have in front of it 12 inches of teak and 1½ inches of skin. We must not forget, however, that a projectile whose apex only is ·2 inches clear through the iron, and whose head is still held fast in it, must not be treated as if only backing and skin were left for it to pierce. On this species of reasoning 140 would seem a fair guess at the penetrating force. Again, the Plymouth breakwater shield with 15-inch plates, was completely pierced in August, 1870, by a blow of 114·4. The complicated structure, the Russian "Hercules" ought to represent as great resistance as class A_2, and she has been also brought to an estimate of 140. None of these experiments are such as we would desire for our purpose. No. 33 is the best representative target, although considered by some to be bad of its kind. Pending further experiments, we can hardly better our estimate of 140 as given on the diagram.

For the thick armour recently ordered for the "Thunderer," we have with a figure of 185·5, the point of a shell just showing through No. 35 target fired at at Shoeburyness in May, 1871. This No. 35

target consisted of 14 inches of plates, 15 inches of backing, and $1\frac{1}{4}$ inches of skin. On this, with the result on No. 33 target given above, I have based the 180 line. This line, while perhaps the most important in the diagram, is one of the most difficult to determine. Looking at the firing at No. 35 target alone, the figure might be taken at 186; but this single experiment hardly justifies the subsequent firing at No. 33 target being totally ignored, although no doubt it is less valuable than the proper representative test.

No. 33 has an inch less iron and 3 inches less teak, while it has $\frac{1}{4}$ inch more skin. We have already estimated it at under 139·9. Reckoning the $\frac{1}{4}$-inch skin as equal to 2 inches teak, No. 33 remains inferior to No. 35 by 1 inch of iron and 1 inch of teak, even allowing as much as 30 for this, the figure only rises to 169·9.

This mode of estimation is very unsatisfactory, and it has been said that No. 33 target did not actually represent anything, and, above all, that it contained a brittle plate. To this may be replied, that if the target was to teach nothing, why, in the face of the results obtained at No. 35 in May, 1871, was No. 33 fired at in July, 1871? When once this firing had taken place we have no right to ignore it without sound reason. The badness of the plate was only discovered when it was fired at, and it may be fairly argued that there are many such plates in the sides of our vessels, or at all events plates with the same fault in a less degree. For this is not a fault that either exists in its full extent or not at all. Plates may be brittle in a greater or less measure, and one very brittle plate may be held to indicate the probable existence of several exhibiting the same fault in a less degree; hence it seems sound to attach some weight to the firing at 33 target, enough at all events to bring the figure down to 180. However, in a few weeks' time, when the 35-ton gun is fired at Shoeburyness, better data may be obtained.*

To take another difficult case, that of the "Lord Warden" and "Lord Clyde," class E. A "Lord Warden" target in 1865 was nearly penetrated by a piercing figure of 88·4, while 92·0 penetrated it well. Probably about 90, as estimated by Captain Noble, was the force *just capable* of piercing this target. This firing, however, took place with spherical and cylindrical steel shot; an ogival-headed Palliser projectile would perform much better work. Thus a "Warrior" target in 1865 required a force of 61 to penetrate it, while with the present service Palliser projectiles, 53 is amply sufficient. A reduction of penetrating force in the same proportion for the "Lord Warden" will give the figure 78·2 nearly.

Starting again, to find our figure on another principle:—the 4·5″

* Since the reading of this paper, the following results have been obtained:—

At Shoeburyness, on June 20th, No. 33 target, with an additional 4-inch plate (making 17 inches of iron, 12 of wood, and $1\frac{1}{2}$ skin), was pierced by the 35-ton gun, at 70 yards. In the above, this target (No. 33) is estimated as 139·9. Adding 20 for each inch in the extra plate, 219·9 is obtained as the piercing figure. On this occasion 219, or perhaps less, pierced it well.

At Portland, on July 5th, the "Glatton," turret thick portion (14 inches of iron, 15-inch backing, $1\frac{1}{2}$-inch skin), was nearly pierced by the 25-ton gun at 200 yards, the blow being about 181. These results accord more closely with the table than could have been expected.

plate, which forms the armour proper of the "Lord Warden," requires about 27·1 foot tons to pierce it. The additional support of the backing and skin may be set down at about 55; this would give an aggregate amount of 82·1. Thus, on the whole, if we estimate the piercing figure of the "Lord Warden" as about 80, we are not likely to be far from the mark, although the result is arrived at by a method adopted only in default of more definite data. I shall be happy to give the data as far as I have recorded them, on which I have traced in any line in the table. Even a thoroughly established figure, like that of the "Warrior," is liable to a certain amount of variation. Thus of three "Warrior" targets fired at about the same time, viz., Nos. 28, 25, 22, the first mentioned required nearly 54 to pierce it well, while 51 or 52 appeared to be sufficient for the others. Whether this result be due, as suggested by the Committee, to different degrees of soundness in the backing, or to accident, one of two things must follow: either the same vessel may be penetrated by a rather less blow as she grows older, or else different portions of her side vary sensibly in their powers of resistance. The object of the table, however, is, as I have said, not so much to lay down absolute rules, as to recommend a simple plan on which Officers might deal systematically with the vessels they might encounter, a plan which would admit of being worked out more thoroughly as time goes on, and on which any new line might be at any moment drawn in by anybody who happened to learn the penetrating figure of any ship.

Foreign Armour-Clads.

The figuring and lines printed in red on the diagram refer to armour-clads of foreign Powers, of which I believe those in the table (see Appendix) are on the whole good representatives. It is difficult to estimate the "piercing figures" of the French and American vessels fairly. We have, however, also given some general facts concerning their armour and backing. The French vessels having, as a rule, *no skin*, would be liable to injure their crews to unusual extent by splintering. The laminated armour possessed by most American ships is very inferior to solid plates of the same thickness. The results obtained at Shoeburyness seemed to indicate that a solid plate of 4 inches thickness was very superior to 6 inches made up of $\frac{5}{8}$-inch plates. Sufficient experiments, however, have not been carried out to establish a trustworthy comparison between solid and laminated armour, and on this account, as well as the peculiar application of armour-stringers, it is difficult to estimate the figures for American ships. Another feature in American vessels is the rapid diminution of the armour below the water-line. Mr. Reed points out, in the work above quoted, that at 3 feet below the water-line the "Dictator" has only a single inch-thickness of armour, and the "Kalamazoo," at 2 feet 9 inches, has 3 inches only. Clearly it would be well to aim at American vessels below the water-line. Lastly, we may notice that the armour in American turrets is not thickened in the manner pursued by ourselves. As to the other foreigners, the Russian "Hercules" is a gigantic design both as to guns and armour, and ought to be a most formidable ship whenever

she is afloat. The Austrian ships afloat are weak generally in armour at present. This would be remarkable, for the very name of the "Lissa" reminds us that Austrian armour-clads have really fought, and any preference shown by Austria for light armour would deserve special notice; but Count Dubsky, in answer to my inquiries at the Austrian Embassy, has kindly informed me that they have two really heavily-clad vessels now in construction. I do not know exactly what backing these vessels have to their armour, but I conclude we may place them somewhere between the "Cyclops" and "Hercules" classes.

The Danish Minister has kindly obtained the information given with reference to the Danish Navy. It may be seen they have some vessels with a high class of armour, ranking about classes C and D.

In speaking of the diagram giving information in a form easily grasped, it may be well to make what may be called an incidental use of it, for example:—

We want to determine the best gun for a certain fort. We see that if we employ the 12-ton gun we can only keep vessels of the "Cyclops" class at a distance of a little over 400 yards, but if we like to go as far as 18 tons, this class must fall back to a range of over 2,000 yards. So, again, if we want to defend a space of 3,000 yards against the Russian "Hercules," we see that for this we must employ a 35-ton gun.

Again, let us compare the respective performances of the guns by means of the "Hercules" trace. This vessel is too much for the 9-inch gun even at the muzzle, but the 10-inch drives her back to nearly 1,200 yards. The 12-inch of 25 tons is generally beaten by the 11-inch gun, but at the short ranges it has an advantage. The bend and slight advance forward which the lines A_2, B, and C make when passing from the 11-inch gun and coming opposite to the 12-inch, is a feature that must not be overlooked, but it is easily explained. The weights of the 11- and 12-inch guns are identical, so are their firing charges, therefore it is not surprising that the projectile of the latter, although weighing only 535 lbs., should keep up its velocity better than the 600-lb. shell of the former, the surfaces of resistance being nearly in the proportions of 10 to 12, while the weights are in the proportion 10·7 to 12. The circumstance that the 11-inch gun is of later introduction, and in fact rather supersedes the 12-inch, would account for some improvement in proportions. At the same time, there is no use in shutting our eyes to the fact that the difference with common shrapnel shells would have been very much more marked. The 12-inch gun supplies one of those instances where the evil of running the risk of making mistakes was preferred to the evil of submitting a question to the mathematical referee of the Committee, the result being the introduction of a gun with a twist which was insufficient to keep its proper 600-lb. common and shrapnel shell point first; so that there exists a mixture of 495 and 600 lb. projectiles with corresponding differences in ranges or elevations. This arrangement, and their remarkable case shot, we may look upon as the Woolwich guns' contribution to the "queer things of the Service." But to return to our subject.

As time goes on, it appears possible that the lines may be found to

approach a little too close to the guns, because the projectiles gradually improve; and although we may not adopt the suggestion of the Committee that the ships deteriorate to a sensible degree, yet they cannot be expected to improve by keeping. On the other hand, the estimate in the table, which is based on the supposition of the best projectiles yet made being fired, may be found too high for some of those still existing in our equipments and those of foreign nations.

Perhaps I have sufficiently explained the table, I will pass on to its use on service.

I will suppose a case. I am in a small iron-protected fort, witnessing the approach of a short, handy-looking vessel with a spur bow. I cannot expect to be able to say exactly what she is and what armour she carries, but there is enough about her to make me guess her as falling somewhere between the classes B and E.

My armament I will suppose to consist of one 10-inch and two 7-inch guns. It is hardly possible, I say to myself, she can be a vessel of such strength as our English "Hercules;" in fact, I think, looking at my table, I ought at all events to stand a good change of piercing her at a mile range with my 10-inch gun. Possibly I cannot pierce her at any distance with my 7-inch guns. I will assume that she must approach within a mile range to effect any good purpose. I decide, then, to reserve my 10-inch gun, and in the mean time to feel her sides, and learn all I can, with my two 7-inch pieces. First, is she an armour-clad at all, or only passing herself off as such, and approaching a certain distance for some investigating purpose? To ascertain this I fire Palliser shells at her. Should I observe a distinct burst against her side I know she must be armour-clad, as these shells, having no fuzes, cannot act on impact against wood or thin iron. If, after repeated hits, no burst occurs, we conclude she is wooden and change to common shells, and open at once with the 10-inch gun in addition to the others. Should she on the other hand prove to be armour-clad, we continue with the two 7-inch guns only, not so much with the hope of piercing her as of effecting smaller injuries, getting her range, finding out her present rate of speed exactly, and taking her return fire. At a mile range the 10-inch gun, well and deliberately laid, opens on her, when it would depend on what she is and what is her object, whether she could push her course further, or what would become of her.

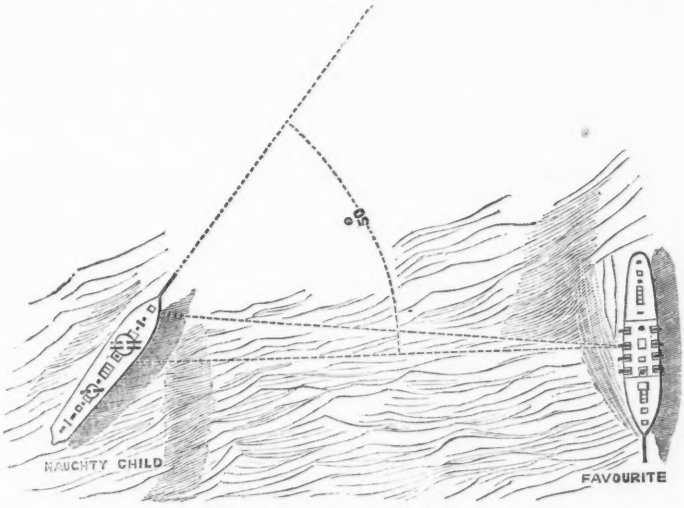
It may be objected that by only firing my 7-inch guns I may lose the opportunity of piercing the armour of a ship which may draw off before coming within a mile. On the other hand, is it not possible that before attempting a passage up a channel with various classes of ships, some very heavily clad vessel might be ordered to stand in and feel the fire of the fort? Knowing the range at which she was struck, and observing the indentations in her armour, it would become easy to lay down how near each ship in the fleet might approach the fort, supposing the latter put forth her full power against any vessel that approached.

Again we come to the question of where to aim?

I believe I am right in considering that the opportunity of hitting a

vessel between wind and water when engaging her from the windward side is now no longer offered, because vessels would not fight under canvas, and instead of heeling over would only be subject to a little rolling, and that probably not sufficient to give any real opening for a blow either below the water line or over one side into the deck, or backing and interior of the other side, at least so I understand from the naval Officers whom I have questioned on the matter. In the case of a battery in an elevated position, however, it would probably be right to watch for an opportunity of firing shell so as to strike the deck or interior of the backing beyond. The bursting a shell so fired might be expected to be very destructive, because the armour would drive the explosion into the interior of the ship. Common shell, however, would have to be resorted to, for it is a question whether Palliser shells, fired as they are without fuzes, would explode under these circumstances. The late Lieutenant Boxer, R.N., advocated the employment of percussion fuzes in the plugs of Palliser shells, and some experiments were carried out at Shoeburyness relative to his proposal, but, after achieving some success, he was discouraged from continuing his efforts in this direction. As it appears as if it were specially difficult to injure a well-constructed vessel along her water-line, in her engines, or in her rudder or propeller, under ordinary circumstances, it is hard to say at what part of a vessel we ought to point our guns. Some time since I asked an American naval Officer where his experience would lead him to advise me to aim. To which he replied, "You must hit her where you can." Now, although it may be admitted that the difficulty of selecting a spot at which to fire may be great, indiscriminate firing can hardly be advocated under any circumstances. Indeed, were there no other recommendation, systematic firing would be more likely to lead to learning something definite than mere chance shooting, and is, therefore, to be preferred. In certain cases, however, there seems room for decided preference as to where to aim. Take the case of class A, that of the "Devastation" and "Thunderer." It has recently been decided to strengthen the turrets and the armour in their vicinity very considerably, consequently it would be desirable to strike the side of the vessel rather than the turret, and what is true of these ships is, in a less degree, true of most turret vessels. The side is almost entirely below water, but now that the power of projectiles has enormously increased, while water, of course, remains unaltered, it is much more feasible to deliver a blow well below the water-line than formerly. With turret ships, then, it seems probable that the best plan to pursue would be to aim at the water below midships or elsewhere. In the "Hercules" and other vessels, to say nothing of the "Warrior," I believe the armour is thinner at the quarter than midships, a fact which would deserve consideration. Then again the port-holes are to be considered. Now that they are made so small, no doubt it would be very difficult to send a shell through them, but I presume this should be the aim of a gun which is known to be powerless to pierce the armour. Lastly, failing a more definite object, it would surely be well to fire at that portion of the ship where the armour is presented so as to receive the most direct blow. To

explain: in Fig. 2 are roughly given the plans of two vessels taken from Mr. Fairbairn's work on iron ship building; the "Favourite," and Captain Coles' hypothetical vessel the "Naughty Child." It may be



seen that the latter ship is shown firing her guns at an angle of 50° with her keel, while the former is shooting right abeam. Under these circumstances the projectiles of the "Favourite" striking the greater part of the "Naughty Child's" side, would have their power of penetration very greatly reduced; in fact it is doubtful whether shell would not glance off, and shot would undoubtedly do so. It would be a digression here to discuss the question of the impact of shot on armour at an angle. It is probably well known and accepted by most of those present, that at a very oblique angle the projectile glances off point first. At one rather less oblique, it is apt, even after the point catches, to turn too rapidly, and to have too little penetrating power to become *encastrè*, so that it wheels off base first, but rapidly turning end for end. In either case the projectile must carry away a large portion of the work stored up in it, so that the blow on the armour must have been comparatively slight (*vide* Mr. Mallet's papers in the *Engineer*). We may say confidently, however, that there is no chance of a projectile penetrating even sufficiently to turn it in its flight and throw it off, whirling in the manner above noticed, if it impinges on armour at an angle much more oblique than the tangent to the curve of its head at the apex. It is true that a considerable amount of injury has been done to thin plates of iron (an inch or half an inch thick) by projectiles striking at an angle as oblique as 8° (*vide* the experiments conducted against deck plates at Shoeburyness on May 3rd and 5th,

1871), but the projectiles glanced off, the shells in fact not receiving a sufficient blow to explode these charges: so that although a certain amount of rending occurred, nothing that could be called penetration, nothing that could produce much effect on real armour-plates took place. The experiments that have been carried out with a view to penetration into iron when striking at an angle, seem to support Mr. Mallet's statement. Tangents to the curve of the service ogival-headed projectiles at the apex would form the following angles with the axis in each case. With a head struck with a radius of $1\frac{1}{4}$ diameters, 53°, 8′, and with that of $1\frac{1}{2}$ diameters, 48°, 12′. The latter form is that now given to all Palliser shell, and in the case of the larger calibres to Palliser shot also. It becomes a question then, whether even the shell would bite and become *encastrè*, and at all events, a turn of a few more degrees would settle the doubt. Under such circumstances, the "Favourite's" only chance of obtaining penetration would be to strike the "Naughty Child" between bow and quarter, at the point where the dotted line in the figure forms a normal to the curve. It would be interesting to proceed further, to speculate upon the wisdom of a ship always engaging an adversary so as to fire at an angle to her keel, and so to present her armour at an inclined position. In smooth water this would, I should think, be more successfully carried out than when there was any sea on, because in the latter case the rolling of the ship would alter not only the elevation of the guns, but their line also; and it might thus be more difficult to make good shooting. Then again comes the question whether a ship could manœuvre so as to draw a damaged part of her armour out of the fire of her adversary, a consideration which might be more important if she was subject to a racking fire than a punching one, because in the latter case the damage is confined to a small spot which is hardly likely to be struck a second time. Lastly, it may be asked, how far may the crew of a ship be injured by the flying off of bolts and nuts from the impact of shot whose power is not sufficient to give actual penetration? However, I have gone far enough to indicate the direction in which I believe information is much required, such information perhaps as many naval Officer could, in a great measure, supply, but such as I do not think is to be found in any work that is accessible to Officers generally.

APPENDIX.

LIST OF BRITISH ARMOUR-CLAD VESSELS, WITH THICKNESS OF ARMOUR BACKING AND SKIN, TAKEN PRINCIPALLY FROM MR. REED'S "IRON-CLAD SHIPS," BUT CLASSIFIED ACCORDING TO THE BLOW PER INCH OF SHOT'S CIRCUMFERENCE ESTIMATED AS SUFFICIENT TO PIERCE EACH DESCRIPTION OF ARMOUR.

Name of vessel.	Thickness of armour in inches.	Thickness of backing in inches.	Thickness of skin in inches.
CLASS A, 180 AND 140:			
Thunderer (T.*) thick portions	14	15	1¼
Devastation (T.)	12	18	1½
Glatton (T.)			
Fury (T.)	?	7	?
CLASS B, 130:			
Hercules	9 to 6	12 to 10	1½
Sultan	9 to 6	12 to 10	1½
Hotspur	11 to 8	12	1¼
Rupert	12 to 11	12	1¼
(The water-line backing much thicker.)			
CLASS C, 110:			
Cyclops (T.)			
Gorgon (T.)	8	10	1½
Hecate (T.)			
Hydra (T.)			
CLASS D, 85:			
Monarch (T.)	7	12	1½
(The Captain belonged to this class.)			
CLASS E, 30 (wood built):			
Lord Warden	4½	31½	1½
Lord Clyde			
CLASS F, 70:			
Bellerophon	6	10	1½
Penelope	6	10	¾
Invincible			
Audacious			
Vanguard	6	10	1¼
Iron Duke			
Swiftsure			
Triumph			
CLASS G, 53:			
Warrior			
Black Prince			
Achilles			
Defence	4½	18	⅝
Resistance			
Hector			
Valiant			
Prince Albert (T.)			

* (T.) indicates a turret-ship.

LIST OF BRITISH ARMOUR-CLAD VESSELS (*continued*).

Name of vessel.	Thickness of armour in inches.	Thickness of backing in inches.	Thickness of skin in inches.
CLASS H, 52:			
Minotaur, Agincourt, Northumberland	5½	9	⅝
CLASS I, 50† (wood built):			
Royal Sovereign (T.*)	5½	36	nil.
Royal Alfred	6	29½	nil.
Repulse	6	31	nil.
CLASS K, 40† (wood built):			
Caledonia, Prince Consort, Ocean, Royal Oak	4½	29½	nil.
Research, Enterprise	4½	19½	nil.
Pallas	4½	22	nil.
Favourite	4½	26	nil.
Zealous	4½	30½	nil.
(Iron built.)			
Viper, Vixen, Waterwitch	4½	10	½
Scorpion (T.), Wyvern (T.)	4½	9	½

LIST OF CERTAIN FOREIGN ARMOUR-CLAD SHIPS.

French Ships.

Name of vessel.	Thickness of armour in inches.	Backing, &c.	Piercing figure.
Bélier	$8\frac{9}{10}$	For the most part thick backing and no skin.	110 and 85.
Marengo	$7\frac{8}{10}$		85 and 70.
Flandre ?	6		55 and 50.
Taureau	6		55 and 50.
Alma	$5\frac{8}{10}$		55 and 50.
Couronne	4½		53.
Palestro	4½		53.
Gloire	4½		40.
Magenta	4½		40.
Solferino	4½		40.

(Two heavily-clad French ships building.)

* (T.) indicates a turret-ship.

† In these, water can enter when 8 in. or 10 in. of the wood is penetrated.

American Ships.

Kalamazoo	6 (in 3 in. layers) ..	30 in. and 3 stringers, each 8 in. by 8 in.	130.
Dictator ..... Pusitan	6 (in 1 in. plates) ..	42 in. and 3 stringers, each 5 in. by 5 in.	100.
Canonicus .... Miantonomoh.. Monadnock....	5 (in 1 in. plates) ..	27 in. and 2 stringers, 6½ in. by 4 in....	50 to 40.
Passaic ..... Monitor	Ditto	39 in. and 27 in.	50 to 40.

Danish Ships.

No. 56 (building).	8 in. plates	10 in.....	110 (about).
Gorm	7 in. plates	10 in.....	85.
Denmark.....	5 in. plates	18 in.....	70.
Danebrog* .... Pider Skram*..	4½ in. plates.....	28 in.....	40 if wood built without skin.
Lindormen ..... Rolf Krake	5½ and 5 in. plates. 4½ in. plates	10 in..... 10 in.....	Under 55, and downwards, according to skin, &c.

Russian Ship.—The Russian Hercules (The Peter the Great), 140.

Prussian Ships.—Konig Wilhelm, 91; Kron Prinz, 62; Friedrich Karl, 62; Arminius, 40.

Austrian Ships.—Kaiser, 51; Lissa, 51. Building: The Custozza and Archduke Albrecht; perhaps about 120 to 80.

Italian Ships.—Principe Amadeo, 74 and 62; Venezia, 43.

Greek Ship.—King George, 69.

Turkish Ship.—Avni Illa, 69.

Commander W. DAWSON, R.N.: My Lord, Captain Orde Browne need not apologise for treating on naval artillery science before a naval audience, for I know not where the Navy would be in gunnery matters if it were not for the researches and studies of Officers of the Royal Artillery, on whom we are so much dependent for gunnery ideas, as when General Sir Howard Douglas first taught us the elements of artillery science. I have read with much profit the able papers from the pen of Captain Orde Browne in the "Engineer," and am not disappointed in my expectation of hearing to-night a very instructive and very useful paper. The larger table places before us, in a most convenient form, condensed information of a most valuable and important nature, and it will, no doubt, be exceedingly useful to students and instructors for reference, as to the relative values of guns of different calibres, and of the least vulnerable parts of various ships. But there is a wide interval between the relative and the absolute values of objects. And, if we take this table from the student's desk into the battery, and attempt to utilize it for practical artillery fire, it will be found exceedingly misleading, and, therefore, worse than useless. The absolute value of a gun must be the work which it will actually accomplish in battle. The absolute value of a ship is the measure of its indestructibility in action. Now this table of relative values throws very little light on these two practical points, but, on the contrary, egregiously misleads the operative gunner. First, as to the gun, the perforating ranges are worked out on the assumption that the shot will strike at

* Altered to iron-clads.

right angles to the ship's side. This never can occur at sea except by a rare accident. The trajectory of the shot forms an angle, the curvature of the ship's side forms a second angle, the roll of the ship forms a third angle, and the inclination of the ship's course towards or from the trajectory forms a fourth angle. Now, the penetration at angles is the most vital point in nautical artillery science, and on this the great table throws no light. The form of front, moreover, which will perforate at the largest angles is disputable. Mr. Mallet proves mathematically that pointed shot bite at the largest angles from the perpendiculars, and the Government have accordingly adopted ogival heads. But I have seen and handled in Sir Joseph Whitworth's office in Pall Mall iron shot and iron plates, by which the angle at which perforation ceases to take place with flat fronted and with sharp pointed shot, has been practically tested. Whitworth shows an iron plate perforated at an angle of 65° from the perpendicular by a flat-headed projectile, six diameters long. He also shows the relative penetrations of projectiles 3½ diameters long, in which the hole is fairly punched at 45° by the flat-headed shell, whilst the ogival-pointed shot of similar dimensions has failed to perforate at the same angle. We have thus certain hard facts on one side, and I should feel obliged to Captain Orde Browne if he could refer me to the hard facts, the experimental data, conducted by the Government which support the conclusion arrived at on their side, that pointed shot perforate at the largest angles.

Again, perforation is seriously affected by the more or less complete consumption of the charge. Everybody knows that when a gun is repeatedly fired on the same day it becomes heated, and recoils more violently. That increased recoil tells of powder being consumed which was before thrown out of the gun unconsumed. Now, an increased consumption of powder is virtually an enlarged charge, and the increased recoil indicates an increase also of the velocity of the shot, *i.e.*, supposing that the shot is free to escape, and does not wriggle and become obstructed in the bore by vicious rifling. So well is this increased effect on the gun understood, that not one of our heavier guns have been subjected to repeated discharges on the same day. Our 18-ton, 25-ton, and 35-ton guns have never been so tested, lest they should be destroyed by their own wriggling projectiles during their more violent ejection from the bore. But this increase of recoil in the gun, and increase of velocity in the shot, implies increase of penetration as the gun warms. This will suffice to vitiate those refinements of mathematical calculations alluded to in the formation of this table.

Again, it is well known that the endurance of guns is seriously affected by frosty weather, giving brittleness to the material of which they are constructed. Might not the influence of differences of temperature upon armour plating affect also the perforation?

2nd. As to the ships. The strength of any structure is measured by its weakest not by its strongest portion. To tabulate the strongest portion of iron-clad ships, in the form given in the large table is, therefore, most misleading. And I would venture to add that it is a mistake to insert English ships in such a table at all. The British artillerists do not want to punch British ships, but foreign vessels. Let, then, foreign ships be substituted throughout for British vessels, if the table is to be practically useful. But what the British artillerist wants to know is not so much the thickness of the plating on foreign ships, as how it is distributed?—where are the vulnerable parts. Half-a-dozen diagrams hung in every ship's battery, and in every coast battery, would show near enough for the practical purposes of war where the armour is borne in half-a-dozen classes of foreign ships. And if the masts were also shown in the diagrams even a soldier might determine to which class the approaching ship belonged, and where, with reference to the masts, he ought to aim so as to hit the "soft" places. Such diagrams would be most invaluable to artillerists, and such information would be ten times more valuable than one-half of what is taught on board the "Excellent" at this moment. For he would thus learn that it mattered not what gun he had in charge, but that even the projectiles from field guns could sink certain ironclads, if they struck certain portions, and could set fire to others if they struck other portions. They would also learn that the maximum thickness of armour given in Captain Orde Browne's table does not extend over all of even the protected portions, but is limited to a very small area. The gunner would thus learn

what strong portion should be avoided if the ship presented herself at a bad penetrating angle; if the object was too distant for perforation, or if the gun was unequal to such heavy work. Possessed of such information no gunner need despair, whatever his weapon, of injuring, if not destroying, a partially clad adversary.

Again, the armour belts round the water-line are getting narrower and narrower, with every increase of thickness. In this respect the destructibility of a ship is, therefore, increased in proportion to what Captain Orde Browne estimates to be her invulnerability. For example, some ships carry their armour belts but four feet below and two feet above their water-lines. Now, in fine weather, with the ordinary ocean swell, the fore part of the ship commonly rises out of water at each pitch and roll more than double four feet, and "sends" below the water more than double two feet. Let the artillerymen plant a small shot immediately above or below the armour belt, near the bow, and the boasted invulnerability comes to nothing, or, rather, helps to carry the ship to the bottom.

Again, should foreigners copy our "Devastation" turret ships, the exact study of the position of the armour plating will become still more essential to the artillerist. Such a ship coming near the forts on Staddon Heights or Maker Heights, at Plymouth, would be easily destroyed by plunging fire, if our artillerymen know anything about armour, and should she be encountered by a badly armed British ship, our seamen gunners ought to know the utter waste of strength involved in hitting at certain parts, and the ease with which intelligence and skill could plant projectiles from the smaller guns into the vulnerable portions. For example, a small shell grazing the top of the turret on the lower or lee side, would enter the turret, destroy the gun-carriages, and render the vessel, as to artillery, helpless. If, thus disarmed, the turret ship attempted to ram and failed, the British seamen who failed to sink her with a plunging fire skilfully directed would pass down in history as examples of imperfect gunnery training.

Invaluable, then, as Captain Orde Browne's table is to students in deciding the relative values of various guns, and of the least vulnerable portions of various armoured ships, it would be most misleading to the practical artillerist who relied upon it in directing the fire of guns, whether we consider the absolute powers of their projectiles or the destructibility of the ironclad ships referred to.

Lord LAUDERDALE: I think we are much indebted to Captain Browne for the interesting and instructive paper he has read, and in which he has set forth in a tabulated form the penetration of armour plates by the various guns now in use in the service, by shot fired at right angles direct, and although the diagram does not give the penetration at various angles, still it will be a very useful table; there is no doubt that it is a most important point to ascertain the effect of shot fired at considerable angles, as in naval actions ships will endeavour as much as possible to avoid exposing their direct broadside to the enemy. .

The subject of penetration of armour plates has generally been discussed as simply a matter between the guns and plates, but this appears to me to be a mistake; the gun is certainly the main instrument, but much depends upon the form and temper of the shot, and the nature of the powder used. I believe I was one of the first to carry out the experiments at Portsmouth against iron plates; we began by firing common round shot, and found they always broke up and would not penetrate the 4-inch plates. Wrought-iron shot were then tried, but they would not penetrate, but flattened against the plates. Elongated pointed shot were then fired from the rifled guns, but they also failed to penetrate the 6-inch plates, the points generally giving way, and it was not until Major Palliser came to our assistance with his *hard-pointed* chilled shot that we succeeded, but even then shot when fired from the 18- and 25-ton guns seldom penetrated the 12- and 15-inch plates, owing, in my opinion, to the shot always breaking up, for after penetrating 9 or 11 inches the points were found sticking in the plate quite uninjured, but the other part of the shot was reduced to powder; my belief is that those shot would have gone through the plates if they had not broken up. I have lately been informed that the shot are now so cast that only the points are chilled, and the rear is so tempered that they do not break up. Again, much depends upon the nature of the powder used for the large rifled guns; the common L.G. will not give the velocity that pebble powder will give.

With regard to the penetration of shot when fired at various angles against iron

plates, it is yet a disputed point whether *flat*-headed or pointed shot are the most efficient. Many advocate the flat-headed shot, amongst others Sir J. Whitworth, and I believe the French and most foreign nations use the flat-headed shot, but they also have pointed shot for *direct* fire; there is no doubt that the flat-headed are the most efficient when fired through water, the only objection that I know is that when fired under ordinary circumstances, they are not so true at long ranges as the pointed shot.

Captain ORDE BROWNE: I think Captain Dawson's first observation referred to the plan of the diagram. Captain Dawson observes that a vessel's armour would never be struck *exactly* at right angles, and frequently at an angle of incidence so oblique that the calculations shown on the table could not hold good. This objection is valid, nevertheless I would point out that the relation between the force to punch a plate direct, and that required to do so at an angle, appears to be a simple one.* Any attempt to show the force required by each class of armour at many angles would enormously complicate the diagram. It appears to me preferable to have it in its simple form, which gives a good basis to which any rule of thumb may be applied, according to judgment.†

Captain Dawson next raised the question of the relative powers of flat-headed and ogival-headed projectiles striking armour at an angle. It would be easy to discuss this question theoretically at great length. As, however, it hardly comes within the range of the subjects touched on by the paper, it would be better not to do so. Captain Dawson, however, asks for the results of the experiments on which ogival-headed shot have been preferred for angle firing. It is difficult to give these, because although a great deal of firing at angles has taken place with each kind by itself, I believe no actual public competitive trial has ever been made. The paper of Sir J. Whitworth, quoted by Captain Dawson, is an account of a private trial made by him of his own projectiles, so that it would not be fair to put it on the ground of an experiment conducted at Shoeburyness.‡ I believe I am correct in saying that Major Palliser long since invited Sir J. Whitworth to a public competitive trial of the powers of their respective projectiles when fired at armour at angles.

In the last competitive direct firing, Sir J. Whitworth employed a projectile with an ogival head, as well as a flat-headed one. I believe the *ogival* one obtained the greatest penetration he has ever achieved. As concerns the diagram, the supposition that the penetrating powers of shot vary as the number of foot tons per inch circumference, would be more truly correct in the case of a flat-headed projectile than an ogival one, for a flat-headed bolt must be supposed to act very much like a punch, and to cause the plate to give way by cutting a disc out of it, in doing which the shot has actually to shear the plate along the line in contact with the circumference of its head; the action of an ogival head is different (*vide* a paper written by Lieutenant English, R.E.), and the law assumed less correct.

Captain Dawson's suggestion of a diagram showing the weak parts of foreign armour-clads is a valuable one, and might well be carried out; some difficulty may be anticipated in obtaining all the information concerning vessels like the French and American, which are built abroad, but such a table is exactly the kind of thing that I believe is needed for the service.§

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* It has been said that the penetrating force required varies inversely with the size of the angle of incidence. Sometimes this nearly agrees with the results of experiment; for example, in December, 1866 a "Warrior" target at 60° required 65·0 foot tons to pierce it—65 × 8 in 60 = 56, which is very nearly the force required at that time to pierce the "Warrior" direct.

† A vessel may generally be struck at one point at a normal to her side if desired, as instanced in the supposed case of the "Favourite" and "Naughty Child."

‡ On Oct. 8th (since the reading of this paper), Sir J. Whitworth tried his new 9-pounder breech-loader publicly at Southport, with which gun he drove a flat-headed projectile through a 3 inch plate, at an angle of 45°.

§ The objection against furnishing the lines of our own ships on the diagram belonging to this paper, is met by the reflection that it is as important that our vessels should know where they are *liable to be pierced* as where they can pierce others. Again, to make sure of piercing a ship's side, we must know her maximum thickness, a weak place must at best be an uncertainty.

LECTURE.

Friday, 14th June, 1872.

VICE-ADMIRAL OMMANNEY, C.B., F.R.S., in the Chair.

PRACTICAL NAUTICAL SURVEYING.

By Staff-Commander THOMAS A. HULL, R.N.,

Hydrographical Department, Admiralty.

THE object of this paper is to enable an Officer possessing the ordinary knowledge of his duties as a sailor and navigator, aided by the usual instruments found on board every man-of-war, to construct a plan of a bay or harbour, detect errors in the chart of a piece of coast line, or frame a report on a newly discovered island, rock, or shoal. Such contributions to knowledge, although standing only in the relation of sketches when compared with finished surveys, still may, in the absence of better information, be of great assistance to his fellow seamen, and qualify him for employment in a branch of the service which has been second to none in placing and maintaining the British Navy in its prominent position among the forces of civilization.

An Officer having passed his examinations for a Lieutenant may feel a desire to retain the knowledge he must have acquired in navigation, and may wish to gain some experience in nautical surveying. The first step to insure real success and self-reliance in the art, is to do what I am quite content to term *educating himself down to it*, by mastering such simplicities as every day arithmetic, since readiness in the first four rules, proportion, vulgar fractions, and decimals are of the greatest use to the practical nautical surveyor, and are in fact necessary to enable him to use logarithmic tables. Euclid's first four books, with a part of the sixth, algebra, as far as simple equations, are also required to enable him to use practical trigonometry. These studies may be lightened by practical geometry, as treated by Raper in pages 21 to 32 of his "Practice of Navigation," thereby gaining facility in handling those powerful instruments the scale and compasses. In working problems for practice in plane trigonometry, every triangle should be projected, and the problem solved by construction as well as calculation.

The ordinary problems of navigation thus handled elevate themselves

into nautical surveying. Take for instance a common day's work, in which (see Diagram 1) a vessel contending with adverse winds has made six tacks, which, corrected for variation and deviation give the following true courses, viz.: W.S.W. 16 m, S.E. by E.$\frac{1}{2}$E. 10 m, W. by S. 11 m, S.E. 24 m, E.S.E. 10 m, and S.W. by W. 24 m. Draw the meridian line AD, and lay off from a known position at A an angle of 67° 30′, from south towards the west, Aa is then drawn, and made equal to 16 m, the first distance. At a, from aA, an angle of 50° 37′ is laid off towards the east, equal to 4$\frac{1}{2}$ points, or the angle between E.N.E. and S.E. by E.$\frac{1}{2}$E., and ab made equal to 10 m; at b an angle of 39° 22′ is laid off equal to 3$\frac{1}{2}$ points, or the angle between N.W. by W.$\frac{1}{2}$W. and W. by S., and bc made equal to 11 m; similarly the other angles and distances are laid off till the point C is reached, and CD is drawn at right angles to AD.

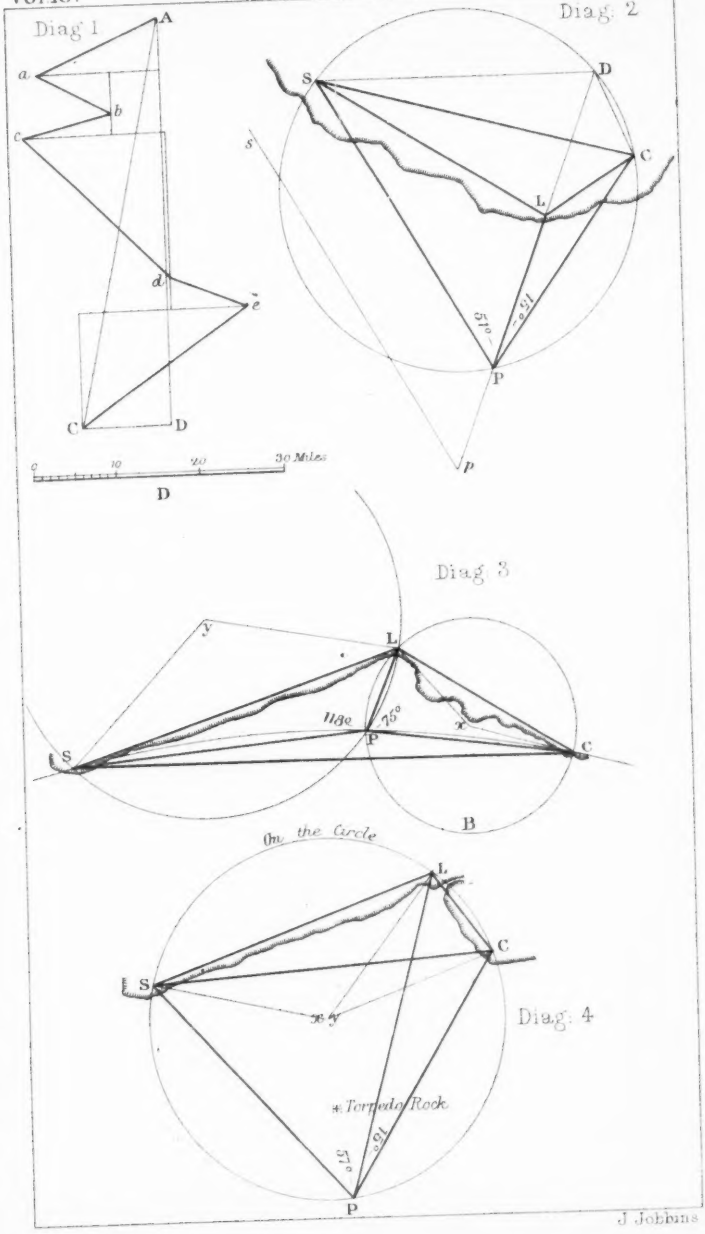
Supposing, as is often the case, no current has been experienced, a triangulation has been thrown over the water, the triangles being right angled; or the courses and distances represent the true bearings and distances taken and calculated from time to time in an ordinary survey. Assisted by the traverse table the triangles are worked out, and the position of C found trigonometrically; this is checked by comparison with the position obtained at C, by astronomical observations. The departure can be turned into diff.-long., and the sheet graduated as in the actual survey of a coast. Thus navigators become surveyors in spite of themselves, and triangulate without knowing they are doing so.

Necessary Geometry.—When in sight of land a common method of fixing a ship or boat is by observing two objects that are in transit, *i.e.*, situated in the same line as the ship or boat, and taking an angle between them and some well known object to the right or left, taking care that the angle measured is not less than 25°. A line is then ruled through the objects in transit, any point is taken in it, and from this the angle observed is laid off in the direction of the third object; a line, ruled through that object, parallel to the line forming the angle, will intersect the line ruled through the objects in transit on the position of the ship.

Thus in Diagram 2, two points, D and L, whose positions are known, are observed to be in transit from a station P, and an angle LPS of 51° is measured between them and a third known point S; through D and L a line DLp is drawn, and at any point p in that line, an angle Dps, equal to 51°, is laid off towards S, and a line ps drawn; then through S a line SP is drawn parallel to sp, cutting DLp in P, the position required.

Diagrams Nos. 2, 3, and 4 illustrate certain questions in nautical surveying on which some time may be most profitably spent, as they represent the means whereby positions may be fixed, and are, therefore, of the greatest use to both navigator and surveyor, especially in the determination of positions afloat.

These questions are solved by means of the 20th, and the 21st, or 22nd propositions of the III, and the 5th of the IV books of Euclid.


Diag 1
A
a
b
c
d
e
C
D
0
10
20
30 Miles
D
Diag 2
S
D
s
C
L
51°
128°
P
p
Diag 3
y
L
118°
75°
x
S
P
C
B
On the Circle
L
C
S
x & y
Diag 4
* Tornado Rock
51°
75°
P

J Jobbins

The 20th proves that *the angle at the centre of a circle is double of the angle at the circumference upon the same base, that is, upon the same part of the circumference.*

The 21st proves that *the angles in the same segment of a circle are equal to one another.*

The 22nd proves that *the opposite angles of any quadrilateral figure inscribed in a circle are together equal to two right angles,* and

The 5th of the IV shows how *to describe a circle about a given triangle.*

Sailing along a coast three objects are observed—the tall chimney of a factory (C), a lighthouse (L), and the spire of a church (S), (see Diagram 2); the bearings and distances between these objects can be obtained from the chart. It is required to fix the position of the ship by angles measured from her between the points C and L, and also between L and S, the former being 15°, the latter 51°, the assistance of station pointer or tracing paper not being available.

Projecting by Circle and Line of Direction.—Join CS, and at C, on the opposite side of CS to that on which the ship is situated, make the angle SCD equal to 51°, or the angle subtended at the ship by the line SL. Similarly at S make the angle CSD equal to 15°, or the angle subtended at the ship by the line CL. The intersection of these lines gives a point D. About the triangle SDC describe the circle SDCP, and through L draw the line DLP, cutting the circle SDCP in P.

The point P will be the position required.

Join PC, PS; then DPC and DSC, being angles in the same segment, DSPC are equal; DSC was constructed equal to 15°, therefore CPL, the angle between the chimney and the lighthouse, must equal 15°. For similar reasons SPD and DCS, being angles in the same segment, DCPS are also equal, and LPS the angle between the lighthouse and the church spire, must equal 51°, and thus the position required has been found.

Projecting by Circles.—In the 3rd Diagram as one of the angles exceeds 90° another method must be followed. The angles measured in this case are 75° between C and L, and 118° between L and S.

From L and C on the same side of the line LC as that on which the ship lies, lay off the angles CL*x* and LC*x*, each equal to 15°, the complement of the angle subtended by CL; the intersection of these lines gives a point *x*, then with *x* as a centre and *x*L as radius describe the circle LPBC.

Subtract 90° from 118°, the angle subtended by SL, and from S and L, on the opposite side of the line SL to that on which the ship is situated lay off the angles LS*y* and SL*y*, each equal to the 28° thus obtained; the intersection of these lines gives a point *y*; then with *y* as a centre and *y*L as radius describe a circle LPSD, cutting the circle LPBC in P.

The point P will be the position required.

Join PC, PL, and PS, then because *y* is the centre of the circle SDLP, the angle S*y*L at the centre standing on the same part of the

circumference SDL as LPS is therefore double of LPS. Now SyL, or the angle at y towards D, equals 236°, the angle at y inside the triangle SyL having been made equal to 124°, therefore the angle LPS equals $\frac{236}{2}$° or 118°, the angle required; and because x is the centre of the circle LPBC, the angle LxC at the centre standing on the same part of the circumference LC as LPC is therefore double of LPC; now LxC by construction equals 150°, therefore LPC equals $\frac{150}{2}$° or 75°, the angle required.

A third circle may be drawn through C and S, its centre being on the opposite side of the line CS to that of the station L, having an angle at the circumference equal to 167°, or 360° − (118° + 75°); this circle, by cutting either of the others more directly, determines the point P with greater exactness.

In working for practice the above examples should be solved by calculation as well as construction.

The position of a ship may always be found by the method shown in Diagram 3, or by the intersection of the circles, but in many cases with one large angle (but less than 90°), and a small angle, or with two small angles; the method shown in Diagram 2, however, will be found more convenient.

Care must be taken that the objects used in fixing a position are situated in such a manner that the centres of the circles used in the 3rd Diagram to find the point P are sufficiently remote, as otherwise the circumferences will so nearly coincide as to render it difficult accurately to determine the points of intersection; or that in the 2nd Diagram, D and L are sufficiently remote to ensure the true direction of the line DLP being accurately ruled, as if these points fall too near to each other, a small error in the observed angles will cause a large difference in the position of P; and if the point P cannot readily be found by projection, be sure that no station-pointer or tracing-paper can more easily discover it, and an inexperienced surveyor may bring on board a chart on which the positions of shoals may be erroneously placed, owing to his trusting to three points so situated as to fully mislead him.

On the Circle.—The 4th Diagram may serve to illustrate the difficulties alluded to. It is an instance of a position in which the inexperienced occasionally find themselves known technically as "on the circle."

This occurs when the positions of the observer and of the objects observed, lie actually or very nearly on the circumference of one and the same circle. In the 4th Diagram for instance, the circle passing through C, L, and S, passes also through P, the observer's position; the angles being 15° and 57°. The small angle LSC is therefore equal not only to LPC, but, to any angle in the segment CPSL. In like manner, the large angle LCS is equal not only to LPS, but to any angle in the segment LCPS. Laying off the angles on the opposite side of the line CS, as in the second diagram, to find point D, the triangle thus projected must coincide with the already known triangle SLC, and point D coinciding with point L, no line of direction

DLP can be drawn. If the method of the intersecting circles in the 3rd Diagram is used, the centres x and y must also coincide, because the objects and the position of the observer all lie on the circumference of the same circle.

Round the segment CPS, endless time may be wasted with station pointer or tracing paper in a fruitless endeavour to find the position of P, because, as shown above, CL and LS must subtend angles of 15° and 57° respectively, to any point taken in the segment CPS.

No other object being in sight, the only friend is the mariner's compass, as a bearing taken of one of the points, as of C, N.E., by E., can alone fix the position of the wandering angles.*

In the selection, therefore, of three points to fix a position by, the middle object should, if possible, be the nearest to the observer, or the three objects should be in or near the same straight line, or the observer's position should be within the triangle formed by the three points. But in all cases of doubtful or badly placed points, a third angle, if it can be obtained, or a simple compass bearing of one of the objects, should always be taken.

The 4th Diagram will also show the advantage of using what may be termed a danger angle. Thus, if a rock, the "Torpedo," is known to lie off a coast that has been fairly surveyed, and of which the points can be recognised with certainty, then by taking care on passing the neighbourhood not to increase the angle subtended by too well-defined points as C and S beyond a certain number of degrees, in this case 72°, it will be impossible to approach the shoal. An angle of this sort measured between the Carnero and Frayle towers would have prevented the "Agincourt" touching the Pearl rock; and had the "Lord Clyde" been kept with Pantellaria subtending four to five points, instead of being allowed to close the island until it subtended eleven points, her narrow escape from shipwreck would have been avoided.

Practice on Board Ship.—When making a passage, let every opportunity be taken of observing for time, latitude, and variation. In arriving at the results, avoid applying to the Navigating Officer for such matters as the course and distance between sights and noon, but obtain the required data from the deck log-book, and compare the position thus found, with that entered in *the* log-book. By night the stars should be studied, the names and positions of the principal learnt, and on moonlight nights latitudes from altitudes of stars north and south of the Zenith obtained, with frequent observations in the northern hemisphere of the Pole star.

Time should be found by observing stars just before sunrise or after sunset.

Lunars taken both east and west of the moon, form capital practice in taking angles and using the sextant in awkward positions. The working out of all the above observations affords excellent practice in figures. The dead reckoning should be carefully worked, and daily

* Where a couple of angles are taken to fix a ship running along a coast, or in a harbour, a compass bearing should always be observed at the same time.

current found by comparison of the position obtained from dead reckoning, with that determined by observation.

A track chart of the voyage is another useful piece of practice. I don't mean a chart copied from that in use, but one constructed for the purpose from the table of meridional parts, merely fixing upon it the land that has been seen during the voyage.

On leaving the land be careful to fix the ship and obtain a departure from which to begin the dead reckoning, and on making the land take the first opportunity of fixing the ship's position, thus obtaining an idea of the correctness of the landfall.

All the above work should be carefully entered in a sight-book and work-book, every day's doings in both books being fairly headed by the day of the week, month, and year. Many valuable observations have been lost through omitting to note date and place.

The results, viz.: course and distance run, latitude and longitude by dead reckoning, latitude and longitude by observation, bearing and distance of the nearest land, current experienced, should be fairly written out at the foot of each day's work.

A table of the errors and rates of the chronometers, and a deviation table should also hold places in the work-book.

It may be remarked that this is navigation and not surveying. The answer to such a remark is, that practical nautical surveying is the essence of practical navigation, and a constant attention and practice of the latter is a sure method of acquiring a true knowledge of the former.

Seamanship.—In the studies above mentioned the duties of the sailor are by no means to be neglected, and every opportunity should be taken of handling the ship, and observing how she may be conducted in or out of port. No man can expect to attain a trusted position as a nautical surveyor who is not a good sailor, or, to speak more exactly, pilot, knowing the requirements of a ship, and the room she wants to wear, stay, and anchor in. The first lessons of this art are to be learnt in boats—I don't mean mere boat sailing, racing, &c.—but the handling of boats under oars and sail, in fair weather and foul, allowing for the velocity of running water, picking up the ship under weigh, using the anchor, landing in a swell on a rocky, and beaching the boat on a sandy coast. No opportunity should be lost of acquiring this knowledge of boats.

The Sextant.—I have alluded to the power of the compasses and scale when working on paper, the instruments corresponding to these when working on the land or on the water are the sextant and lead-line. The sextant now common, but no less invaluable (whose inventor may be looked upon as one of the greatest benefactors to his race), is to the nautical surveyor what the mariner's compass and anchor are to the navigator and sailor.

It becomes necessary to speak thus of the sextant, because inexperienced men are inclined to look on the theodolite as the nautical surveyor's principal tool. The theodolite can only be used on shore, but the sextant can be used either on shore or afloat.

The nautical surveyor should therefore lose no opportunity of making himself thoroughly conversant with this useful instrument, understanding all its adjustments, peculiarities, causes of error; the size of angles to be safely measured with it, and the means of re-quicksilvering its reflectors.* With the assistance of the sextant, the lost end of the Atlantic cable was found, and without it no ocean can be properly sounded or telegraph cable fairly laid.

When in port, lying at anchor, a simple exercise in using the sextant is to take a round of angles, consisting of six or more, between distinctly seen objects lying nearly in the same horizontal plane, and see how near in addition they may be brought to 360°. Handle the sextant both ways, inverted as well as direct; many objects from being indistinct cannot be reflected from right to left, and the left hand object that can be reflected, must in such case be used. This is often the case in actual practice.

Every opportunity should be taken of fixing the ship on the chart by bearing and angle. Taking it for granted that the harbour in which the vessel is anchored is well surveyed, it is good practice to take angles to the different points, peaks, and islets, and laying the same off from the ship's position, to see if they agree with those on the chart. True bearings of objects, both right and left of the sun, should be frequently observed for practice, taking care that the angle measured between the sun and the object, is always double the altitude of the sun.

If angles are taken between two objects close to each other, care should be taken that they are on the same level, or that the angle measured is nearly horizontal; with large angles, it is of little consequence that the objects used are not on the same level, as the error caused by obliquity is in these cases small.

The Arc of Excess.—It is good practice to measure small angles off as well as on the arc; the arc of excess in most sextants is 5°. Observed masthead angles will generally be less than 5°, and angles of elevation taken to peaks on making the land will always be less than 5°. Taking the angles off and on the arc, adding them together, and dividing by 2, gives an angle free of index error. At sea, measuring the sun's semi-diameter, and comparing that obtained with that given in the Nautical Almanac, renders the observer dexterous in observing small angles with the sextant. If the object is clear and well defined, the inverting tube will be found of great assistance.

Lose no opportunity of volunteering to lay out targets by the masthead angle, taking the angle both off and on the arc of the sextant, that being one of the methods used in nautical surveying for determining an approximate base. When the target is moored, if time permits, get a round of angles from it; these plotted on the plan of the harbour will afford an opportunity of testing the accuracy of the base obtained from the mast head angle, taking care to fix the ship's position for the way in which she may be swung, either on leaving or returning on board. The distance of the target may also be checked by using the length of the ship, or a line drawn from her knight-heads to her taffrail as a base

* See Sir E. Belcher's treatise on Nautical Surveying, page 10.

line. The great length of the modern ironclads presents the advantage of a large base in this direction. Two points, one at each end of the ship are taken as far apart as possible, from which two observers can easily see each other; these points should be carefully marked, and the distance between them known and noted for reference. Angles between moderately distant objects and observers standing at these points, can be taken simultaneously from each end of this base, and from these, the required distance may be obtained. This subject of "Base by ship," with useful tables, has been fully treated of by Admiral Ryder in his book, "On Ascertaining Distances from Ships at Sea," a useful little work for the practical nautical surveyor, and which is supplied to every ship.

Practice of Sounding in Boats.—The lines pulled in laying out the target may be also sounded, the lead line being measured on leaving and returning to the ship. The time must in this case be noted, so that the soundings may be reduced to low-water spring-tides, as those on the chart are all given for that state of the tide. To ensure the line thus sounded being a straight line, the ship should either be kept in transit with some object beyond her, or two points that are in transit in the direction towards which the target is to be laid, should be selected before leaving the ship. The soundings obtained, compared with those marked on the chart, will give evidence of the correctness of the work.

This performance will also show that some little practice and method is required on the part of the man heaving the lead from the boat, and also on the part of the Officer, to determine, first when an "up and down" cast can be obtained without lying on the oars, and secondly, when it may be necessary to stop the boat altogether. In the boat, as in the ship, the end of the lead-line should always be secured before beginning to sound, and care should be taken that "a boat's lead" is taken from the ship for this work, with the necessary tallow for arming, as the nature of the bottom should always be noted.

Measuring Distances by Sound.—The morning and evening gun fired at most ports will afford an opportunity of practising measuring base by sound. The ship being fixed, her distance may be measured on the chart from the fort where the gun is fired, and compared with the result obtained by noting the interval of time between the flash and report of the gun. (See page 729.)

The Standard Compass.—No opportunity should be lost of being present when the ship is being swung for local deviation. The practical rules for ascertaining and applying the deviations of the compass caused by the iron in a ship should be carefully studied, the Officer thereby acquiring a thorough knowledge of the use of that heart of a ship, her standard compass. This instrument is of the greatest assistance in examining a portion of a coast, making a rough sketch of a bay or harbour, or sounding round islands and shoals that may require examination in the course of a voyage.

Artificial Horizon.—In using the artificial horizon care must be taken in pouring out the quicksilver. Sir Edward Belcher, at page 8 of his "Nautical Surveying," gives the following useful hints:—"Place the "finger over the orifice of the bottle, and give it a shake in an "inverted position, holding it over the trough previously cleaned. "Ease the finger, and allow the mercury to flow gently, keeping the "bottle inverted, and taking care to stop the opening of the bottle "before the last portion with the dross flows. This will produce a "clear brilliant surface."

In pointing the horizon towards the sun, see that the shadow is thrown directly behind it, and not on either side. The spot chosen for making these observations should be sheltered from the wind, and, to be free from vibration, removed from traffic. The roof of the artificial horizon should be so placed that the same part is always towards the observer. A mark may be made on the glass or on the frame work to insure this precaution being carried out.

Observations at Night.—Obtaining latitudes at night with the artificial horizon requires some practice; see that it is placed in the true meridian before the observations are commenced. A handy man should be trained to hold the dark lanthorn, by which the observations must be first noted by the watch, and then read from the sextant, in such a manner that, while the assistant who is taking time can see the watch, no light is thrown in the direction of the artificial horizon. On the time being secured, the light is taken to the observer with the sextant. Practice is required both in holding the lanthorn and in reading off.

Astronomical Observations.—Every opportunity should be taken to practise the rating of chronometers by equal altitudes, failing that, by a.m. or p.m. sights, taking care to work a.m. with a.m. and p.m. with p.m. In making these observations, the eye-piece of the inverting tube should, if possible, be used instead of the shades of the sextant; if shades are used, endeavour always to use the same. The meridian altitude of the sun should be taken with the eye-piece, as the latitude obtained from it can then be meaned more satisfactorily with those determined by the stars.

To obtain latitudes from sun and stars, circum-meridional altitudes are generally used, taken from 20 minutes before, to 15 minutes after, the meridian passage, working them out by the method given in Inman's Tables, Introduction, page IX. The approximate mean times of the meridian passages of sun or star should be calculated from the "Nautical Almanac," the error on mean time of the watch in use should then be applied to them; these times of the meridian passage of sun or star, as shown by the watch in use, should be entered in the sight book as a guide to the observer. When at sea, stars of the first magnitude are generally taken; but on shore those of the second magnitude may be advantageously used. The study of the position of the stars at sea, before advocated, will now be found of the greatest assistance.

In the northern hemisphere, several sets of observations of the Pole-

Star may be taken to work against latitudes from meridian altitudes of stars south of the zenith. In the southern hemisphere, stars both north and south of the zenith must be taken, and the latitude determined from their mean result.

The watch used on these occasions should for the day be carried in a box, and not kept in the pocket, care being taken to compare it with the standard chronometer on leaving and returning to the ship both in the forenoon and afternoon.

Drawing is a useful accomplishment to a surveyor, but the mistake must not be made that a draughtsman is a surveyor. Sir Edward Belcher has remarked that "any draughtsman can make a neat showy "plan, but it is useless if it cannot stand the seaman's test." If the Officer has a natural talent for drawing, let him by all means encourage it, copying plans of ports from published surveys, and practising the signs and abbreviations adopted in the Admiralty charts and used by the Admiralty draughtsmen, in all cases confining his abilities to the bare facts before him. Few mistakes are more mischievous in a survey than those committed by the accomplished draughtsman who allows his fertile fingers to wander from his facts, and to produce a *pretty* plan instead of a *trustworthy* survey.

Sketches of headlands should be made on leaving and making the land, taking care that magnetic bearings of well-defined peaks and points are always obtained and inserted on the sketch. Sketches of leading and clearing marks are also most valuable, the magnetic bearings being written against them. In harbour, panoramas from the ship should be drawn, the surveyor confining the work to the land only, and avoiding sketches of boats, or shipping, remembering that the object in view is not a picture, but a ground plan or survey of the port.

When sailing along a coast, it is good practice to observe how the points, peaks, and prominent features of the land change their aspect with a change of bearing. To know a place as the same when the bearing has changed some eight points, is a difficult matter to beginners, but is of great value in nautical surveying. This knowledge may be acquired by vigilantly watching the prominent points and observing the gradual change. Although mistakes will frequently be made, and the most promising points turn out failures, becoming lost and undistinguishable, yet those that are recognised will fully repay the trouble bestowed upon them.

Equipment of Boat.—It is supposed that a boat has been granted for the purpose. Care should be taken in her equipment. Dockyard rigs are the best, and all fancy rigs should be avoided. A spare hand should be asked for when sounding is to be undertaken. The following list of gear will be found useful:—

Two leads and lines, the latter marked to feet as far as 5 fathoms, one line being 40 fathoms long; the leads, one to weigh 14 lbs., and the other 7 lbs.; a spare lead of 7 lbs.
Anchor, with cable of 30 fathoms.

Yoke lines sufficiently long to allow of the boat being steered by the feet.

Bag of lime, whitewash-brush, bucket, and bailer. Slow-match. Matches. Strand of junk for stops. Old canvas or old black bags to make marks on the shore. Tallow for arming.

Two slung 56 lbs. pigs of ballast for mooring-buoy. An axe and crowbar.

Boat's compass, pocket compass, sextant; patent log fitted, so that the box part may be lashed on to the gunwale of the boat, a longer fly line being required; note book, sketch book, drawing instruments, small board, tracing paper, penknife, india-rubber, haversack, telescope or binoculars, watch, pocket sextant, slings for sextant box, and a station-pointer if it can be obtained.

Two barécas, one with water and one fitted as a buoy.

Practical Hints.—As there is generally a little climbing to be done in nautical surveying, and as there may be difficulties in landing, it is advisable to have the sextant case, glass, &c., fitted with slings to put over the shoulder, the note book, &c., should be kept in a haversack to be carried by the Officer. This ensures the hands being free in climbing, landing, and embarking. If instruments are being carried in the boat, they should be placed on the gratings at the bottom of the boat, and not on the thwarts, thereby avoiding the risk of injury from falling. Cushions and all dandy gear should be left on board the ship, as they will only be found in the way. The men should be in clean working dress, with blanket frocks in the tropics, and trained to be handy in taking off their shoes, not to be afraid of wetting their feet if necessary in landing or embarking, the Officer setting the example, being as ready to risk his comfort in surveying as he would be in shooting. Gun, powder, and shot had better be left on board the ship, the gun complaint being very dangerous to the real success of the nautical surveyor.

The Boat's Crew.—It will be of great assistance to an Officer thus training for practical surveying, to study the men who compose his boat's crew.

Let him make himself acquainted with how far they can fairly pull in a day's sounding, exercise them in lowering and hoisting the sail, tacking, and wearing, getting the mast up and down, as smartness in these matters will often give them a spell from the oars, and enable the Officer readily to find the position of a shoal cast, obtained in a line of soundings.

Without descending to what is called philanthropy, courting popularity, interfering too much with their domestic arrangements, or in any way departing from the necessary discipline of the service, let him interest himself in their habits of comfortably getting their breakfast before leaving, and their supper on returning to the ship. As taking their dinners already cooked away in the boat greatly facilitates the work, let him at first see they get their gear into the boat for this purpose, so as not to find when three miles to leeward of the ship that the rum, biscuit, or water has been left behind.

The boat's crew will soon learn to look after these matters, and although it will always be the Officer's especial business to see there is fresh water in the boat, the men themselves must be made to answer for such articles as rum or biscuit. In arranging the work for the day, if opportunity offers, and the nature of the coast permits, let him foresee where they may be landed during the dinner hour, as such a change forms a pleasant break, and taking a pot away, driftwood may be found, and the dinner warmed up.

The coxswain will probably soon be able to assist the Officer in noting, one of the crew will quickly learn to watch the tide pole, others will pick up the method of measuring the base-line and prove sharp in pointing out transits that are coming on or stations that there may be a difficulty in discerning.

Thus interest begets interest, and the Officer will soon find himself surrounded by hands and eyes ever ready to assist him.

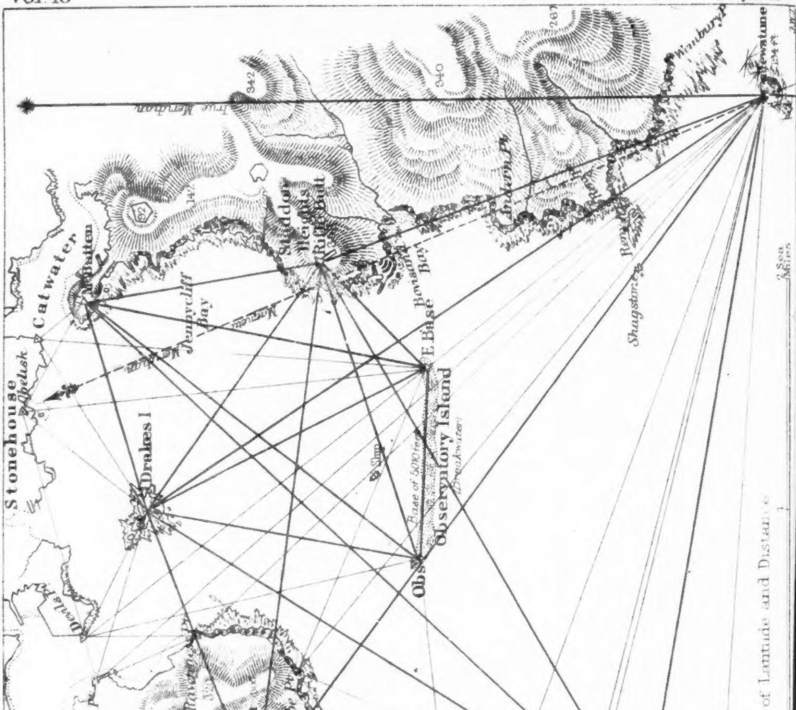
In Nautical surveying, as in all other arts, it is attention to small matters that mainly secures success. No work or duty should be despised because it is small or trivial. A glance at nature will show that nothing is beneath the notice of the Great Surveyor of the Universe, the microscope proving that the mechanism of the spider and the bee are as well ordered and as exquisitely finished, as the mechanism of man.

Having thus shown some of the preparatory studies and exercises necessary to qualify an Officer to undertake a small survey, an attempt will now be made at a plan.

The Triangulation of Plymouth Sound.—Plymouth Sound has been selected as a model harbour on which the principles of triangulation and sounding may be explained. The breakwater will be supposed to be a natural instead of an artificial creation and formed of sand instead of stone; its position, sandy beach, &c., causes the surveyor to use it as an "Observatory island" where he can get his sights, put up his tide pole, and measure his base. The first day may be devoted in pulling or sailing if possible round the Sound, erecting stations on the prominent points, and acquiring a general knowledge of the locality that will be found very useful in the course of the work.

Stations may be erected by whitewashing points of rocks, and building cairns of stones, which must be always whitewashed. Driftwood will often be found of which good marks may be made. An old hammock lashed at the head and foot to cross-pieces of wood and these lashed on to an upright about the length of a boat's mast, the heel secured by a pile of stones or by driftwood, or an old bag stuffed with leaves and lashed to the pole, the whole being whitewashed on the sea face, form marks easily seen and recognized. Advantage should be taken of buildings erected in prominent positions which may be made stations of.* As a rule, round buildings will show out better than square ones,

* In the Syrian survey the Nebys or small Mahomedan tombs built on the hills and along the sea shore being generally dome-shaped and whitewashed, proved of the greatest service.


PLYMOUTH SOUND
(Triangulated)
Obsy Station { Lat. 50.20.00 N / Long. 4. 9. 30 W.
Magnetic Variation
H W F & C
Springs rise 15 ft Neaps 12 ft.
Figures on the Land, shew the height in feet above High Water
Hamoaze
Millbrook Lake
Stonehouse
Obelisk
Catwater
Mt. Batten
Jennycliff Bay
Drakes I.
Obs.
Observatory Island
(Breakwater)
E. Base
Bovisand Bay
Staddon Heights
True Meridian
Wembury Pt.
Mewstone
Shagstone
Pier Cove
Kingsand
Maker Heights
Rame Head
Scale of Latitude and Distance
Sea Miles

J. Jobbin

and in erecting stations, care should be taken not to place them in positions where they are likely to be shaded from the sun.

In carrying on the survey, work as much as possible with the sun at your back; thus, in the Sound, the angles should be obtained on the eastern shore in the forenoon and on the western in the afternoon.

The result of the first day's work has been to fix upon the following prominent points on which stations have been erected where the position is not sufficiently marked by natural or artificial means (see Plymouth Sound triangulated):—

The Mewstone, the Shagstone, the rifle-butt on Staddon Heights, Mount Batten, Drake's Island, the Hoe, Devil's Point, Ravenness Point, Picklecomb Point, Maker Church, Cawsand, Penlee Point, Folly Hill, Rame Chapel. The Breakwater Lighthouse, will be named as the Observatory Station and the Beacon the east base; the supposed beach between these two stations on Observatory Island affording at low water an eligible flat on which to measure the base.

Surveying a port where the names are unknown, points, islands, bluffs, &c., taken as stations, should all be named, and the practice of lettering or numbering be avoided; naming each station after some incident connected with it or its character, as Cliff Station, Beach Station, Bay Island, Leading Hill, Bald Mound, or Dead-tree Bluff; this precaution will be found of great assistance to the memory in the course of the work.

Observing the Angles.—Starting as early as possible from the ship for the Mewstone, so as to work on that side of the Sound in the forenoon, the soundings between the East base and the Shagstone give indications of shoal water in that channel. Arrived at the Mewstone and the summit gained, a true and magnetic bearing of some low but prominent station as the Observatory, is the first thing to be obtained. The rifle butt on Staddon Heights is then evidently the best object to reflect round and use as a zero or initial point of the angles to be measured, taking care not to reflect it to objects at the water-line that are within 20°; such, for instance, as East base, as in that case the obliquity of the angle may introduce an error.

Angles are then measured to Drake's Island, Devil and Wilderness Points, which will make as entrances to Hamoaze. Ravenness Point, which will probably show out black against the trees behind it; Picklecombe Point, distinguished by its fort; the Observatory Station; the Shagstone, Maker Church, Cawsand, Folly Hill, and Penlee Tower (which two last will be nearly in line), Penlee Point, and Rame Chapel: East base will then be reflected to the Observatory, thus completing the angles to stations from the Mewstone.

Angles will next be taken between the Observatory and the tangents* under Staddon: thus Reny Point will be reflected to the Observatory, then each side of the island off it, then Staddon Point, which will be probably seen over Reny Point, the words "seen over" being written in the angle book. The nearest part of Wembury Point, the bight

* Tangent is a term used in surveying describing a line drawn from the eye to touch the points of the coast, or the edges of reefs or shoals; an angle being measured between that line and one drawn to a station or fixed point.

between it and Reny Point; the bight of Bovisand Bay also "seen over," and the east tangent of Observatory Island. The rifle butt may now be used and taken to prominent points on the Cawsand Bay shore, such as bluffs, cliffs, patches of sand, conspicuous houses, extremes of beaches, and anything that there may be a probability of again recognizing. The coast guard under Lower Hams, the rocks at Pier Cove, will probably show out. The cliff at Amory Bight, the neck of Rame Head and its outer tangent will complete this part of the work. A few angles should then be taken to the prominent hills and their shoulders, the run of the valley behind Cawsand, and the fall of the hills over Ravenness, so as to give some idea of the topography. A rough plan should be sketched of the Mewstone and its vicinity with the rocks off it, lines being taken to the little Mewstone.

The Shagstone will next be visited and a few angles taken to ensure giving some idea of the adjacent coast. From the Shagstone, pull as close along the shore as possible, sounding, noting the courses steered, the distances run, and sketching the nature of the shore. Arriving at Staddon Point, the heights must be ascended, and angles taken from the rifle butt on the same system as that pursued at the Mewstone; taking care to stand as nearly as possible in the position or against the same part of the butt, to which, and from which, the angles taken at the Mewstone were reflected. In visiting the other stations similar care must be taken, as it is of the greatest importance that the angles should be measured from the exact point to which they were taken; Mount Batten will here form a good object to reflect as far as Penlee Point, after which Penlee Point itself should be used to get the angles round to the Mewstone. In thus shifting the object reflected, care must be taken that such objects are always connected; in this case, for instance, the angle between Mount Batten and Penlee must be carefully measured.

Angles are then taken to the bight of Jenny-cliff Bay, the high and low tangents of Drake's Island, with the cliffs, bluffs, houses, and conspicuous points taken from Mewstone. From the rifle butt a panoramic sketch of the Sound should be made to the best of the Officer's ability; never mind how rough may be the production, it will often serve to remind him of points in the work and prove most useful to him in projecting the survey.

Mount Batten will next be visited, the coast between Staddon and Mount Batten being pulled along and sketched in as before. Maker Church will here form a good point to reflect, taking care to use the Observatory when observing to points, &c., under the Church, and also to observe from that part of Mount Batten to which the angles were taken.

Thus each station will in turn be visited, the angles obtained, and the coast pulled along and sketched in between.

True and magnetic bearings should if possible be observed from one of the stations in the afternoon, to check those obtained from the Mewstone in the morning.

It should be arranged, if possible, that the angles from one of the stations visited in the day should be taken at low water, when, what is

called low-water tangents, or lines from the station to the low-water extremes of the coast with its rocky or sandy points and beaches, should be obtained.

If in the port during spring tides, the greatest trouble should be taken to obtain these necessary lines from at least three prominent positions.

Getting out the Triangles.—Supposing that all the stations have been visited and the angles obtained, the next process is to get out the triangles it is intended to use, commencing with one of the largest, in the following manner:—

TRIANGULATION OF PLYMOUTH SOUND.

No. of triangle.	Stations.	Angles observed.	No. of triangle.	Stations.	Angles observed.
		° ′			° ′
1	Mewstone	59 55	7 ..	Rifle butt	38 00
	Penlee Point.....	40 45		Penlee Point.....	55 20
	Rifle butt	79 20		Maker Church†....	86 40
		180 00			180 00
2	Mewstone	46 40	8 ..	Drake's Island	63 30
	Penlee Point.....	68 50		Rifle butt	54 35
	Drake's Island	64 35		Observatory	62 00
		180 05			180 05
3	Penlee Point.....	28 05	9 ..	Drake's Island	115 55
	Rifle butt	66 15		Mount Batten	36 50
	Drake's Island	85 40		Observatory	27 15
		180 00			180 00
4	Drake's Island	52 26	10 ..	Drake's Island	80 15
	Rifle butt	44 45		Mount Batten	62 45
	Mount Batten	82 45		East base	37 00
		179 56			180 00
5*....	Drake's Island	138 00	11 ..	Observatory	83 40
	Penlee Point.....	10 46		East base	60 35
	Mount Batten	31 15		Drake's Island	35 40
		180 01			179 55
6	Mewstone	27 00	12 ..	Observatory	21 55
	Penlee Point.....	96 00		East base	130 35
	Maker Church† ..	57 00		Rifle butt	27 30
		180 00			180 00

And so on for the minor stations.

* Ill-conditioned triangle. † Calculated angle.

As some points in a survey, although they may be prominent positions in the plan, are likely to be inaccessible, trees or other causes preventing the angles being observed from them, triangles which have one of these stations at their angles are said to possess a calculated angle, as such angles can only be obtained by that method; greater care is therefore used when taking an angle to a place that cannot be visited. In this survey Maker Church and the Folly Hill are fixed by calculated angles. In tabulating the triangles, such angles should be written in red ink.

It is evident that if the angles have been correctly taken at the several stations that the sum of these angles will be for each triangle 180°. Instrumental error, obliquity, personal error, and other imperfections generally prevent this happy result, and the Officer may be content if his sums are not less than 179° 55′ or more than 180° 5′.

The method of getting out the angles of these triangles is as follows:—In triangle (2) at the Mewstone, Staddon rifle butt was taken to Drake's Island, the angle being 13° 15′, and then to Penlee Point; the angle being 59° 55′, from which 13° 15′ being taken, leaves 46° 40′, the angle required. This process may be termed the reduction of the angles. But it may be asked, why was not Drake's Island taken at once to Penlee? Because Drake's Island, having the buildings of Plymouth behind it, was a bad object to reflect and the rifle butt was a good object to reflect; also it was not advisable to shift the zero.

At Drake's Island we have Penlee Point taken to the Mewstone, Penlee being a good object to reflect, and at Penlee we have Mewstone taken to Drake's Island for similar reasons.

In some of the triangles the angles will be found at once in the angle book, and from most of the stations used in the triangulation the angles required will easily be obtained by simple reduction. If these calculations are made at the main stations in the course of the work, much after-trouble and vexation will be prevented. For instance, if in getting the angles at Penlee, having already observed the angles at the Mewstone, the rifle butt, and Drake's Island, the triangles Nos. 1, 2 and 3 are proved on the spot, the angles at Penlee are at least certain of being taken correctly, and any error will be known as not to have been made at that station. At the same time the numerous small sums required to be worked will show the necessity—remarked upon in the commencement of this paper,—for the would-be nautical surveyor educating himself downwards, and mastering such simplicities as every-day arithmetic; thus the roots of his work, like those of the oak, penetrating the soil more deeply than those of other trees, ensure to his labours a solidity and durability similar to that attained by the monarch of the forest.

All the angles of the triangles having been sorted in the above manner, any error in the observation will be readily detected and such triangle scored as faulty; the angle wherein the error lies may possibly be detected in the course of the work. Triangles having an angle in them of less than 25° are to be looked on as ill-conditioned, and more than usual care should be taken in laying off and ruling a line *likely to cut another at a less angle than* 25°.

Projecting the Triangulation.—The work taken from the ground, or

the angles and observations obtained by the above system, has now to be projected or placed upon paper. Drawing-paper of the size required may be stretched in readiness. This process is well described by Heather in his Treatise on Mathematical Instruments, page 64 of the seventh edition.* It is a good plan to first form some idea of the bay or harbour by a rough plan projected on a sheet of common cartridge paper.

A prick made on the lower right hand corner will represent the Mewstone, through which draw a long straight line parallel to the perpendicular edge of the paper to represent the true meridian, and another line at an angle of 21° 25′ to the left for the magnetic meridian. The true bearing of the rifle butt, N. 19° 15′ W., obtained by reduction, or its magnetic bearing, N. 2° 10′ E., if no true bearing has been obtained, is next laid off. An estimated distance of the rifle butt from the Mewstone has been formed by its being about as far from the Mewstone as the ship, which latter distance (Mewstone to ship) was determined by mast-head angle. Using this as an approximate base, the rifle butt is taken at $2\frac{1}{4}$ miles from the Mewstone, which at 6 inches to the mile equals $13\frac{1}{2}$ inches; a prick is therefore made on the line drawn to the rifle butt from the Mewstone at that distance to represent the rifle butt.

At the Mewstone an angle of 59° 55′ is next laid off from the line to the rifle butt, in the direction of Penlee Point. At the rifle butt an angle of 79° 20′ is next laid off from the line to the Mewstone in the direction of Penlee Point, the intersection of these lines if carefully drawn will be Penlee Point; on this intersection the protractor should next be laid and the angle measured on the paper between the Mewstone and the rifle butt; if this is 40° 45′ the work is right, a prick should be made in the paper to represent Penlee Point, and the projection may be proceeded with, but do not leave Penlee Point without feeling sure that the angle between the Mewstone and rifle butt measures, as nearly as the protractor will show, 40° 45′, which was the angle observed there.

From the Mewstone and Penlee Point the angles 46° 40′ and 68° 50′ are next respectively laid off and the converging lines drawn, their point of intersection will be Drake's Island; here repeat the operation of testing the angle at Drake's Island, being sure it contains the proper number of degrees, viz., 64° 35′. Four points, the Mewstone, the rifle butt, Penlee Point, and Drake's Island, now appear on the paper. The work is further tried by another test on the following plan:—At Drake's Island the angle measured between Penlee and the rifle butt was found to be 85° 40′; 85° 40′ is accordingly laid off at Drake's Island from the line to Penlee Point and a line drawn to the rifle butt; if this line does not fairly pass through the prick in the paper representing the rifle butt some error has been made, and the work must be carefully gone over again to discover the mistake. Should it pass fairly through the rifle butt the work may be proceeded with, but woe to the tyro who fails to insure the accuracy of his first four points.

Maker Church, Mount Batten, the Observatory, and East Base are

* A useful work to the practical nautical surveyor, published at 1*s.* by Virtue Brothers and Co., 1, Amen Corner, Paternoster Row.

next fixed on similar principles, and then the minor stations, until the whole network of the triangles is laid down, remembering that no station can be considered as fixed before it has been fairly cut in from three or more well-determined stations.

Caution.—This is main triangulation, and if this is carefully and honestly projected, the rest of the work will fall into its place with ease, and that important part of the survey, the soundings, will be readily laid down; but no words can express the confusion worse confounded, the chaotic mixture of right and wrong, the untold annoyance, vexation, loss of temper, and temptation to fudge that will assuredly arise, if in these apparently minor and simple details, the greatest care is not taken, and every effort used to insure accuracy, in thus laying the foundation of the work.

Straight Lines.—I dwell forcibly on these common place matters, apparently adapted to the simple capacity of the industrious, from observing the difficulty most beginners find in drawing a straight line. To draw a long straight line requires all the attention of the practised surveyor. Heather, in his treatise on mathematical instruments, at page 66, gives some excellent rules on drawing lines. Rulers must be tested to see that they are straight, and surveying vessels are supplied with a plain steel ruler, known as a straight edge, used solely for the purpose of drawing straight lines.

To ascertain that a Ruler is Straight.—Carefully draw on a flat table between two points marked on the paper a line nearly as long as the ruler, first with the edge of the ruler turned towards you, and then with the edge of it turned from you. If the ruler is true the lines will coincide, but if not they will enclose a space.

Detail.—From the fixed stations the angles taken to conspicuous houses, trees, peaks, and cliffs, with the tangents of the points and islands, and the lines to the bights of bays and extremities of beaches are laid off, cutting the objects in, if possible, from three stations, the islands being drawn within the limits enclosed by the tangents, as in the case of Drake's Island and the Mewstone; such secondary points fixed, the coast line sketched in the boat while pulling round the sound from station to station, will be easily laid down. The fixed peaks, with the panoramas sketched from two or more points will permit of some idea of the topography being given, and thus the detail of the work will be completed.

Sounding.—We now come to the most important part of a nautical surveyor's duty, on which his character mainly depends, viz., the soundings. Without these figures the work before described is of little service to the sailor. A plan of a port without soundings may be compared to a pretty purse with no coin in it, useful only to him who knows how to fill it.

The importance of sounding is not sufficiently considered by young surveyors. They have a superstition that any fellow can sound, and

Officers wishing to obtain an insight into nautical surveying have been disgusted at being sent to learn to sound. But while the land work may be done by the soldier or civil engineer, the sounding is the sailor's portion, requiring all the ready wit and tact of his profession. In sounding the sailor has to manage air and water, the rise and fall of the tides, the velocity of currents, and to fit in his work to suit wind and weather; these forces becoming firm allies to the man who studies them, and foes only to him who knows not how to use them.

The Lead Line, by means of which the soundings are obtained, should be looked upon and treated as a valuable instrument, and, therefore, to be used for no other purpose but sounding, except in the absence of a chain for measuring a base line, or ascertaining the height of a cliff.

A good plan is to take for this purpose a ship's line that has been some little time in use, and is therefore well stretched, marking it to feet as far as five fathoms, on the same principal that the ordinary line is marked to fathoms, with 2 knots at 20 feet, and a bit of leather at 4 fathoms, or 24 feet.

The line should be always measured on leaving and returning to the ship. If obliged to use a new line, and shoal water is found, the line should be remeasured in the boat, on the boat-hook marked to feet * Men should be accustomed to heave the lead from the boats, and should be narrowly watched when fresh at the work, in order to ensure their giving the correct soundings. The foremost awning-stanchion shipped forms a good support to the leadsman's breast rope. The end of the lead line is to be secured before beginning to sound, and care should be taken that all hands take a fair turn at the lead.

Noting.—The soundings should be noted at equal intervals and distances. If a patent log cannot be obtained, this must be done by the judgment of the Officer, by time or strokes of the oars. Under five fathoms the lead should be hove continuously, and the boat's position fixed near the three and five-fathom line at low water on approaching and leaving the land.

A space must be left underneath the figures of the soundings in the angle book in which they may be reduced to low water by a table derived from observations made on the tides, to be presently treated upon. The reduced soundings should be noted in red ink.

The time should be noted whenever angles to fix the boat's position are taken, or at least every half hour. In the absence of a watch, if working within sight of the ship, permission should be obtained for the signal man to hoist a numeral flag every hour, showing the number of the bells struck, keeping the same flying for five minutes, and hoisting the dinner pendant at noon.

Attention in the notation of the time is not only a great assistance to the memory when plotting the soundings, but without it that most delicate and important part of a survey, the reduction of the soundings to low water, cannot be honestly carried out.

* The line should always be marked from the heel of the lead.

The nature of the bottom should be frequently noted, especially marking any changes that may occur, such changes often giving warning of neighbouring shoals.

Selection of Points.—The diagrams treated on in the early part of this paper explain the means whereby the soundings are fixed, as by them has been shown what points may be considered as good, indifferent, or useless. The angles should be taken either to stations or to points fixed in the survey. When ill-conditioned angles are unavoidably used, *i.e.*, if the objects taken lie in any way near the circumference of the circle that passes also through the position of the boat, or when there is any doubt regarding either of the points, a third angle or compass bearing should be obtained as a check. In fixing the boat's position, the angles should be taken as nearly as possible at the same time and in the same place; the points to be used being looked for before reaching the position to be fixed. Sounding in a tide way, or with points difficult to distinguish, it may be necessary to anchor to obtain the fix.

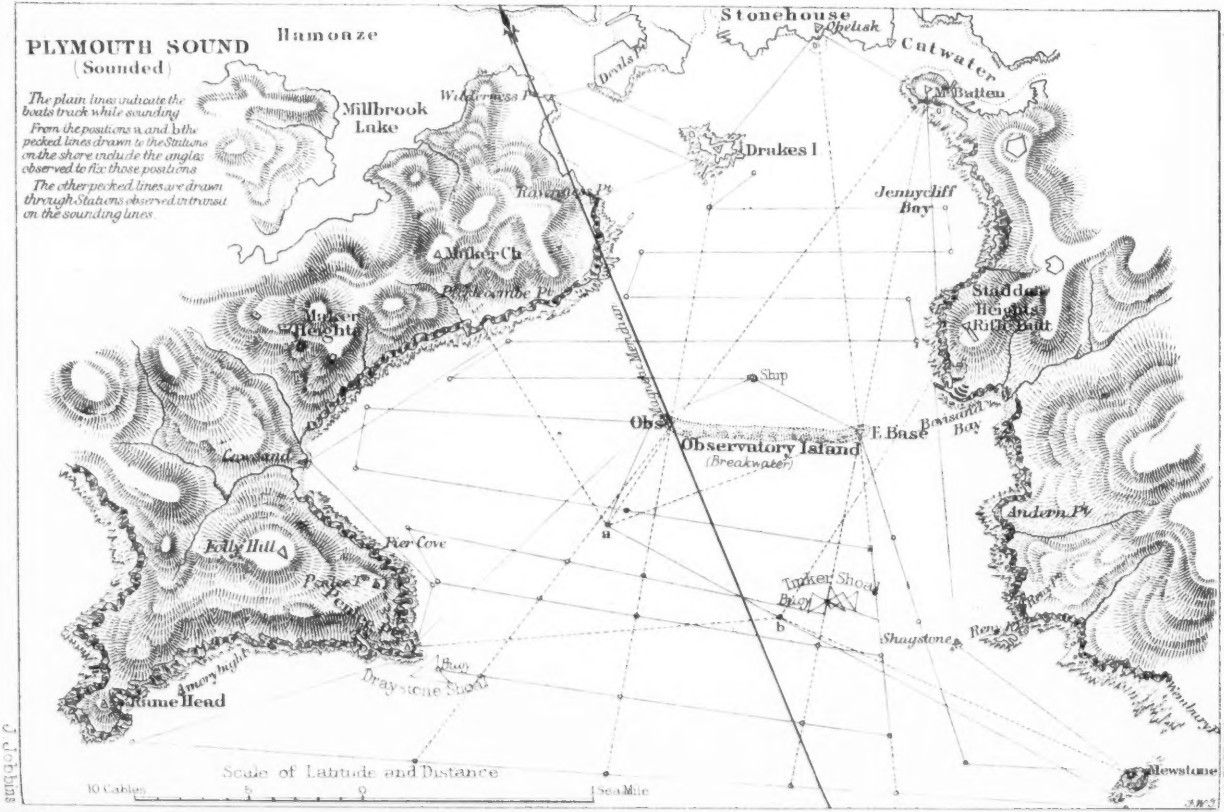
Lines to be Run Parallel.—The lines of soundings should, if circumstances permit, be run parallel to each other, the distance apart being determined by the locality, the nature of the bottom, and the scale on which the plan is being made. In Plymouth Sound, for instance, the outer lines are three cables apart, the inner lines two cables apart.

To ensure these lines being pulled or sailed as straight lines, before starting from a station or fixed point, some well marked object should be found on the shore in line or transit with the point or mark for which it is intended to steer, this second mark lying sufficiently far behind the point steered for to show any deviation from the straight line required. If pulling or sailing to seaward, the same should be looked for astern; such objects kept in transit *must* insure a straight line being followed; on nearing the shore a good look out should be kept for a third object in the same line, in case of the second mark used, dipping behind the foreland. Keeping the boat on known straight lines is the only sure method of sounding in a tide way, often enabling the surveyor to fix his position by one angle only, and is of great assistance to him when there is any difficulty with regard to the objects used.

As there is some difficulty in steering by stern marks, the use of them should be made a point for practice. In all cases the compass-bearing of the points steered for or from, should be noted.

In sounding under sail five fathoms may be obtained without lowering the sail, but if the water is deeper, the sail should be lowered if running free, or the sheet eased off when sailing near the wind, to insure getting an "up and down cast."

Baréca for Beacon.—In the list of boat's gear two barécas have been enumerated, one of which should be fitted as a buoy, with a buoy-rope of about ten fathoms made of lead-line.


PLYMOUTH SOUND
(Sounded)
Hamoaze
The plain lines indicate the boats track while sounding
From the positions a and b the pecked lines drawn to the Stations on the shore include the angles observed to fix those positions
The other pecked lines are drawn through Stations observed in transit on the sounding lines.
Millbrook Lake
Stonehouse
Obelisk
Cutwater
Devils Pt
Wilderness Pt
Drakes I
Mt Batten
Ravenscliff Pt
Jennycliff Bay
Maker Ch
Penlee Pt
Staddon Heights
Rifle Butt
Maker Heights
Ship
Obs
Observatory Island
(Breakwater)
F Base
Bovisand Bay
Cawsand
Andern Pt
Folly Hill
Pier Cove
Penlee Pt
Linker Shoal
Buoy
Shagstone
Rame Head
Draystone Shoal
Scale of Latitude and Distance
10 Cables
5
0
1 Sea Mile
Newstone
J Jefferys

Pl XXV

This buoy is to be used as a beacon when it is required to examine shoal patches lying some distance from the shore, as the Tinker Shoal. The lead-line is bent on to the pig of ballast before alluded to, which will be found sufficient to moor the baréca.

Boat's Anchor.—In using the boat's anchor in surveying, where the boat may frequently be anchored on rocky ground, it is advisable to bend the cable like a buoy-rope to the crown of the anchor, stopping it with spun-yarn to the ring; then if the flukes jamb in the rock the stop will carry away, and the anchor may be weighed with ease. This precaution has saved many a boat's anchor, prevented a return to the ship, and the disarrangement of a well contemplated scheme.

Gaining Local Information.—If the bay or coast to be surveyed is inhabited, take pains to gain the friendship of the fishermen, as these men making their living by their knowledge of localities useful to themselves, but dangerous to shipping, are often able to point out the positions of rocks or foul ground. Boats or canoes fishing should be piously avoided by a vessel coasting or entering a strange port or roadstead, as they are liable to be working in the vicinity of rocks or shoals.

Plotting the Soundings.—By laying another sheet of cartridge paper underneath the rough plan, the points obtained by triangulation may be pricked through, the names written against them, and any lines of soundings already obtained should be ruled on this second rough plan to prevent the work being done twice over.

This sheet may be fixed to a board by tracing-pins and taken away in the boat, so that the lines of soundings may be laid down as obtained by station-pointer, tracing-paper, or projection. If in the absence of station-pointer or tracing-paper the work has to be done by projection, three or four stations should be selected as points liable to be used in fixing, the lines joining them ruled, bisected, and perpendiculars drawn from the point of bisection; the centres of the projecting circles would then be readily found by laying off the complement of the angle taken, from one of the points, the intersection of that line with the perpendicular giving the required centre. Thus perpendiculars might be raised upon lines joining Mewstone and Observatory, rifle butt and Observatory, Observatory and Penlee, and Observatory and Maker Church.

In the first day's preliminary examination of the sound, soundings were obtained in pulling from point to point. On returning from the Mewstone, not wanting to pass over work already done, a line was run in the direction of Penlee Point until the Shagstone coming in line with the tangent of Mount Batten, gave a good opportunity to fix the position of the boat; the next line was run to the northward by keeping the East base in line with a mark on the land; on shoaling the water three feet to the north-west of the Shagstone, that rock was observed to be in line with the north tangent of the Mewstone, on deepening to six fathoms, angles were taken, and from the East base the boat returned to the ship. (See Plymouth Sound sounded.)

The lines of soundings should all be drawn on the rough plan, to prevent the work being done twice, and all work such as main

triangulation, and especially soundings, should be plotted on return to the ship, if possible before sleeping, while the memory is green. It will then be seen where further examination is required, and how the work is progressing.

It may here be remarked that if time or opportunity does not admit of making a survey of a harbour, an idea of its form, extent, and depth of water may be arrived at by simply running lines of soundings from the ship anchored near the centre, to the prominent points, noting at these points the masthead angle and bearing of the ship; thus, in the Sound, a line of soundings might be run from ship to Observatory, masthead angle observed and bearing taken, not only of the ship but of Picklecombe, then a line run from Observatory on the bearing to Picklecombe; on reaching that point, bearing of ship and masthead angle again to be taken and a line run back to ship; leaving ship again for Drake's Island, lines on the same principle could be run, returning to ship from Mount Batten, and so on till the Sound be completed.

Method of Sounding.—It is next required to fairly commence the sounding. Fine weather, with a pleasant breeze from the south-west, suggests the advisability of a day's work outside the Observatory Island to examine the entrance of the Sound. Starting from the ship for the west end of Observatory Island, the leadsman begins to sound on passing the Observatory, the boat pulling S.W. $\frac{1}{2}$ S. on a line dead to windward; on this line the water suddenly shoals six feet, the position is fixed, but the examination is deferred to another time, the shoal lying near the ship and it being desirable not to lose the present good opportunity of running the long outside lines. A quarter of a mile farther on, the water again shoals 12 feet, deepening 15 in less than a cable. Another fix* is obtained, and as the ebb tide is running the mast is got up and sail made for the Mewstone, a reef being taken in to prevent the boat running too fast for the soundings. A course is shaped to keep the gap in the little Mewstone open (S.E. $\frac{1}{2}$ E.) with the forts on Maker Heights in line astern; after a run of about a mile the water shoals a fathom, the bottom being rock; ship swung to the ebb is observed to be in line with Drake's Island, and the position is fixed,† and the next cast gives an increase of a fathom, making the last cast suspicious. On reaching the Mewstone the shoal to the south-west seen from the summit, when the angles were taken, is examined and the extreme fixed.

A long line is now run, N.W. by W. $\frac{3}{4}$ W., for Rame Head, keeping the tangent of the head in line with some mark on the land beyond. In the deep water to be found in this line, the sail must be lowered to get the soundings, which should be obtained at least every five minutes, and the boat fixed when favourable transits occur, such as the East

* Position (a) on "Plymouth Sound" sounded—

East base and Observatory Station	45° 10′	fms.
Observatory Station and Maker Church.	55° 20′	6½ rock.

† Position (b)—

Mewstone and rifle butt.....	86° 40′	fms.
Rifle butt and Penlee Point	120° 50′	8 rock.

base in line with the Hoe obelisk and also with Mount Batten, the Observatory in line with Mount Batten. Arrived off Rame Head, the boat is fixed in three fathoms.

Penlee Point is then sailed for, E. $\frac{1}{4}$ S., keeping it in line with a mark found on the land near Andern Point. Under Penlee Point the fix may not be a good one, but a position will be taken up directly the Sound opens and objects can be seen. A mark on the land beyond the Mewstone having been found in line with the north tangent of the Mewstone, it is steered for, haulyards in hand, ready to lower to get the fix before spoken of; a sudden shoaling of 8 or 9 feet gives warning of a rock. Angles are taken and buoy put over and the mast got down, and the shoal starred by a method that will be presently described. The line is then continued S.E. by E. $\frac{1}{2}$ E. for the Mewstone, lowering the sail as before to get the sounding, the transits being noted and used as in the first line. The East base coming in line with the Hoe obelisk, the position is fixed and the boat run up, N. by E. $\frac{1}{2}$ E., on that line for about three cables, until Folly Hill coming in line with a gully under it, bearing N.W. by W. $\frac{1}{4}$ W., offers a good mark to stand back upon.

Just after the East base comes in line with Mount Batten the water shoals a fathom, a fix is taken, and the angles are found to be nearly the same as those taken in the rocky ground met with in standing towards the Mewstone in the morning. This ground must therefore be examined on return. Fixing under Penlee Tower the forts on Maker Heights are steered for; and after running about a quarter of a mile, the boat is fixed, and the Shagstone touching Wembury Point, bearing S.E. by E., offers a good mark to stand back upon; it being necessary to examine the neighbourhood of the two shoal and rocky casts before mentioned. A shoal cast is obtained when abreast of Observatory, giving warning of the tail of the shoal pulled over in the morning when starting, and when near the suspected locality, with Mount Batten in line with East base, 23 feet is reported.

Starring a Shoal.—It being just low water, a fine opportunity offers to examine this shoal, sail is lowered, mast got down, and a line pulled N.E. by N. for the East base. 15 feet being found, the buoy is put over and the line continued until a depth of 6 fathoms is obtained, a line is then pulled S. by E. until the boat is in 5 fathoms, back to buoy and beyond to 7 fathoms, then S.W. by S. crossing a patch of 18 feet, then back to buoy, and so on until the patch is fairly sounded out, the least water found, and its extremes determined.

The course is then continued for the Shagstone till the East base comes in line with the Hoe obelisk. Running up on this line another shoal of 4½ fathoms is struck, making this entrance to the Sound appear suspiciously foul, angles are taken, and Cawsand Chapel in line with a mark on the hill behind affording a good mark for running west, sail is made, and a line run for those marks. Crossing the suspected ground S.W. of the Observatory Station, several shoals casts are obtained, showing the necessity of further examination of that locality.

The soundings inside the Observatory Island will be obtained on similar principles, the lines being run nearer to each other and pulled instead of sailed. Sounding round Drake's Island and the entrance of Hamoaze will give some idea of river work, the bridge representing the bar; in sounding the bridge, great care should be taken to discover a mark to lead over in the deepest water, the breadth of the channel, and the states of wind and tide in which it should be avoided.

If prevented by weather from using the board, and plotting the soundings in the boat, it is a good plan to rule the proposed lines on the plan and note in the sounding book the courses and distances it is intended to follow and the positions from which the lines should be run. Thus for sounding inside the Observatory the first line is to be run from ship W.N.W. for a mark to the southward of the redoubts over Cawsand, until the tangents of Redding and Mount Batten Points were in line; to the N.E. on that course for three cables until the rifle butt came in line with a battery beneath it, bearing E.N.E. From under the rifle butt run up two cables for Mount Batten, and then run back W.N.W. for the highest cliffs of Redding Point, heading up again two cables for Drake's Island, and so on till the lines required are all laid down. An occasional pair of angles might also be taken off the plan and inserted in the sounding book to ensure taking up the positions and running the lines proposed.

In plotting the soundings with tracing-paper, the paper may be economised and confusion of lines prevented by laying off as many angles as possible from the same point on the paper, that one point being made to take the position of the centre of the station pointer, marking each set or pair of angles laid off with some distinguishing symbol, the second set being known by a line (\), the third by a triangle (△), the fourth by a circle (○), the fifth by a square (□). Thus one sheet of tracing-paper may be used to lay down a considerable quantity of work.

In plotting the reduced soundings count the number of soundings obtained between two fixed positions on the line, and divide that part of the line between those stations into as many parts as there are soundings, so as to enter them evenly on the plan; in the absence of proportional compasses, the sector will assist in this performance.

When the soundings are all laid down, what are called contour lines are drawn round the coasts through the points where three and five fathoms were obtained. Draw similar lines round all the shoals, inking them in as shown in the signs and abbreviations adopted in the charts issued by the Hydrographic Office.

Although the soundings taken under five fathoms are all noted in feet, yet in plotting them on the paper they should be marked in fathoms and quarter fathoms, unless the whole of the soundings are marked in feet. Inside five fathoms the soundings should be entered on the plan to the nearest quarter fathom, outside five and inside ten fathoms, to the nearest half fathom, and outside ten to the nearest fathom.

Elevations.—From stations that are near the level of the sea, angles of elevation might be taken of objects such as Maker Church, Mount

Batten, the rifle butt, the hills over Penlee, and the redoubts over Cawsand. Seated at high-water mark, the observer may frequently detect the high-water mark directly under the objects of which he wishes to know the approximate height, and the vertical angle taken off and on the arc will give him a much better result than he can obtain by mere estimation. If the high-water mark cannot be detected, an angle taken at the water line bringing the object down to the water line will answer the purpose. The height above high water of all rocks and islets, such as the Shagstone and Observatory Island, should always be noted against them. Cliffs can often be measured by the lead line.

Astronomical Observations.—The first fine clear day after arrival should be devoted to sights, and the entire day and part of the night spent on Observatory Island. Sights for equal altitudes, latitude, true bearing, and variation of the compass should be obtained. The Officer's practice during the voyage having made him an expert observer, little difficulty is met with. Rates are obtained from observations taken from five to ten days apart, meaned with those taken at the port last sailed from, and supposing its position to be well known, a meridian distance determined in the following manner:—

MERIDIAN DISTANCE BETWEEN BEIRUT AND SIDON.

Numbers of chronometers.	Dent, 1,793. Standard.	McCabe, 187.	Frodsham, 2,714.
	h. m. s.	h. m. s.	h. m. s.
Standard fast on Beirut mean time, June 17th, 1861	7 15 00·79	7 15 00·79	7 15 00·79
Comparisons (standard being fast on chrs.)	—	9 11 15·00	9 35 15·00
Chronometers fast on Beirut mean time, June 17th, 1861	7 15 00·79	10 03 45·79	9 39 45·79
Ditto Ditto, June 11th, 1861	7 15 11·68	10 03 43·68	9 39 41·68
Rate in six days	10·89	2·11	4·11
Daily rate*	− 1·81	+ ·35	+ ·68
Sidon rates in June	− 1·91	+ ·18	+ ·59
Beirut-Sidon rate	− 1·86	+ ·26	+ ·63
Chronometers fast on Beirut mean time, June 17th, 1861	7 15 00·78	10 03 45·79	9 39 45·79
Rate in three days by Beirut-Sidon rate	− 5·58	+ ·78	+ 1·89
Chronometers fast on Beirut mean time, June 20th	7 14 55·21	10 03 46·57	9 39 47·68
Chronometers fast on Sidon mean time, June 20th	7 15 25·91	10 04 16·91	9 40 18·41
Meridian distance, Beirut and Sidon	30·70	30·34	30·73

* Losing rates are marked −; gaining rates marked +.

s.		
30·70	Long. of Beirut..	35° 29′ 04″ E.
30·34		− 7 39
30·73		
	Long. of Sidon..	35 21 25 E.
177		
30·59 = 7′ 39″		

Latitude of Sidon from five observations of stars south of the Zenith	33° 34 11″ N.
Ditto by five observations of the Pole-Star..	33 34 39 N.
Mean Latitude....	33 34 25 N.

N.B.—The Sidon Observatory was at the southern end of el Jezireh.

The chronometer or watch to be used for observations should be placed in a box and carried with care. Especially avoid giving it a circular motion. The watch should be compared with the standard on leaving and returning to the ship, and all the chronometers should be compared at noon on sight days. For further information on the management of chronometers, and the measurement of meridian distances, see Shadwell on Chronometers.

Tide Pole.—A sheltered corner is found, in which the tide pole may be erected. A broken oar is driven into the sand, and supported by guys of spun yarn, or secured by stones or shot among the rocks, the place chosen being in about 2 feet water at low water, protected as much as possible, and yet with the sea having free access to it. To this oar a painted batten is lashed, conspicuously marked, the alternate feet being painted black and white, the figures 6 inches long, painted black on the white ground, and *v.v.*: such a batten can be read from some distance with a telescope. The time is noted for the rise and fall of every 3 inches, or the state of the pole marked every half hour, great care being taken to determine as near as possible the times of high and low water, by taking a mean of the times at which the water was at equal heights before and after high or low water, on the same principle that apparent noon is found by adding the times of the equal altitudes of the sun together, and dividing by 2. The state of the wind should be always noted.

If in port at the time of the full and change, it is advisable to especially observe the high and low water on that day, remembering also that the greatest rise and fall occur from the third to the fifth tide after the full or change.

On the days that are not spent on Observatory Island, if the tide pole is not near enough to be noted from the ship (which may often be done by means of a telescope), supposing the ship to be moored, and the nature of the bottom at the anchorage level, a good idea of the daily rise and fall may be obtained by noting the depth alongside every

half hour with a lead-line marked to feet, taking care, as before, to obtain as nearly as possible the times of high and low water.

From one or other of these methods of observations, a daily tide table may be made, showing for every hour of the day the number of feet to be subtracted from the soundings taken to reduce them to low-water springs.

The soundings should be reduced very shortly after the return to the ship, and not entered even on the rough before they have been so reduced.

If the ship's stay is not long enough to get the times of high water at the full and change, that fact should be noted on the survey, and the rise and fall termed approximate.

A study of the Admiralty tide tables, and a comparison of the times and heights obtained, with those of some of the ports there given that at the same age of the moon have a similar rise and fall, will enable an observer to form a tolerably correct idea of the necessary amount of reduction.

To determine the rise and fall of the tide, and to reduce the soundings accurately, require very considerable tact, judgment, experience, and patience; and these must not be given grudgingly, as the knowledge of the rise and fall of a foot is often of invaluable service to a sailor in difficulties.

Measuring a Base.—To get a scale for a plan it is necessary to measure a base line. There are several methods by which this may be obtained, which, in the absence of actual measurement by chain or line, may serve to determine a scale sufficiently near for the general purposes of navigation, viz., mast-head angle already treated upon, sound, patent-log, and pacing. The last method, allowing 2½ feet to the step, is a rough method, but infinitely better than putting no scale at all, or one by estimation on the chart.

Circumstances often prevent the base being measured by chain or line, owing to absence of level ground, or even if that is found, its position with regard to the triangulation preventing its being used, in which case one of the other methods must be fallen back on. In all cases the objects or stations erected at both ends of the base must be securely fixed, and connected with the main triangulation. In the case before us, the breakwater or Observatory Island is remarkably well suited for the purpose; rarely, I fear, will a more obliging island be found.

Possessing no chain, some old well stretched lead-line, 200 feet long, is carefully marked when wet to feet, with knots at the tens, half-knots at the fives, and bunting at the fifties, an eye being spliced in each end. When it is to be used, this line must always be wetted. Ten iron pins, made like stout priming wires, should also be procured; they can be made by the blacksmith. At low water, the beach being then dry between the Observatory Station and East base, one hand (Jones) having a flag made fast to the long boat hook, is told to walk from the station in the direction of the East base for nearly a quarter of a mile, keeping a look out on Observatory Station for orders.

On being told to halt, he is beckoned to move a little either to the right or left until he stands to the Officer at Observatory Station directly in line with the East base. The boat hook is then stuck firmly in the sand, and he returns. Jones is next provided with the ten pins and one end of the line, and told to run it out in the direction of East base, by keeping the flag in line with that station. The line run out, he turns round, and is directed to shift his position, if necessary, a little either to the right or left, so as to place him directly in line with the East base; the line is then shaken, to see that it lies straight along the sand, with one end touching the centre of the Observatory Station. He is then ordered to put his pin in the sand at the bare end of the line, and to proceed in the direction of the flag and East base, drawing the line after him, and followed now by a second hand (Smith) who carries the other end of the line, walking at a pace sufficient to keep the line taut, and accompanied by the Officer with note-book. The pin reached, a halt is made; Jones turns round, and gets Smith immediately in line with Observatory, while Smith sees that Jones is in line with the East base. The line is shaken up, the bare end placed against the pin. Jones puts the second pin into the sand, while Smith takes out the first pin, and is ordered to retain it until he can muster ten pins. Meanwhile the Officer enters a stroke thus (/) in his note-book, and orders Jones to proceed as before. The second pin reached, the operation is repeated, Jones putting in a pin, Smith taking up a pin, and the Officer entering a second mark in his book. When the fifth pin is taken out, the mark is made thus (𝍸).

On Jones arriving at the eleventh length, he naturally calls out for more pins. Smith, having ten, gives them to the Officer, who, finding they correspond with the tally 𝍸 𝍸 in his book, knows the work is so far correct, and that 2,000 feet have been measured. The Officer then carries the pins to Jones, and they proceed as before.

In the example before us, the shift of pins occurs twice, and if the work is correctly done, Jones will find himself at the East base, 10 feet beyond the position of the fifth pin of the third batch. The distance between this pin and the centre of the east base is most carefully measured. Smith, taking out the last pin, returns five to the Officer, Jones having the remaining five. The score in the book stands thus:—

Observatory to East base 𝍸 𝍸 𝍸 𝍸 𝍸 and 10, or 5010 feet.

The operation is then repeated, measuring from East base to Observatory, and should agree within two or three feet.

By Mast-head Angle.—If the mast-head angle is used, care must be taken (the ship being a floating and moving object) to obtain the horizontal angles from the same mast of which the angle of elevation is being taken. These horizontal angles are taken between the station on the shore from which the mast-head angle is being measured, and two other stations, one right, the other left of it, every angle of the two triangles being above 25°. These angles should be taken as nearly as possible at the time when the observer on shore is taking the mast-head angle. Meanwhile the observer on shore measures the angle between

the mast used and the two stations taken from that mast on board the ship. A flag or black ball should be hoisted close up to the truck of the mast to be used.

The station on shore from which the mast-head angle is taken should be one near the water line, so that the lower angle at the ship should be as nearly as possible a right angle.

By Sound.—The base may also be measured by sound, in which case as long a distance as possible should be used, and if guns are fired from only one end, the base should be measured on a calm day, or when there is not much wind.

The best method of getting base by sound is first to ascertain the number of times that the watch to be used beats in a minute of time. Most pocket chronometers beat 5 times in 2 seconds, or 150 beats to a minute; common watches vary. The number of beats of the watch ascertained, it is easy to find the number of feet that sound travels in that beat. That number of feet multiplied by the number of beats observed, corrected for temperature (heat accelerating the velocity with which sound travels), will give the distance required.*

To measure base by sound, a little pre-arrangement is necessary. In this case it is understood that the ship will fire three guns to the observer at the Mewstone. On the Officer's reaching the Mewstone, and being quite prepared, a flag is shown; that flag is answered by the ship hoisting the preparative, dipping it when the gun is ready. When the flag at the Mewstone has also been dipped, the flag at the ship is slowly hoisted, and the gun fired on its reaching the truck.

The flag re-hoisted at the Mewstone shows that the Officer is again ready, and the operation is repeated.

A simple method of counting the beats is by binding the watch close to the ear by means of a pocket-handkerchief; this leaves hands and eye free to use glass and note-book. The observer, comfortably placed with his eye on the ship, begins to count on seeing the *flash*, finishing with the *report* of the gun.

As in the former case, angles are taken at the same time at both ship and Mewstone to connect the base with the triangulation. The gun fired should have extreme elevation given to it; and, if possible, guns should be fired from each end of the base.

The patent-log base should, of course, be run at slack water, running the base three or four times to insure accuracy. The error of this instrument may be found by previous experiment in well surveyed ports.

An opportunity to test the patent-logs occurs when ships are running the measured mile.

The base obtained, the next step is to work out the sides of the triangles, checking the work as it is proceeded with by finding an occasional side from two adjacent triangles, remembering that the sum of the angles not being in all cases equal to 180°, the sides found will not quite agree. When one of the longest sides is found, as Penlee Point to the rifle butt, it may be compared with the number of inches

* At a temperature of 32° Fahr., sound travels 1090 feet in a second; acceleration for temperature, 1·19 feet to 1° of Fahr. At 60° Fahr. therefore, sound travels 448 feet in one beat of a chronometer beating 150 times in one minute.

found between those stations on the plan, and the scale of the chart deduced therefrom.

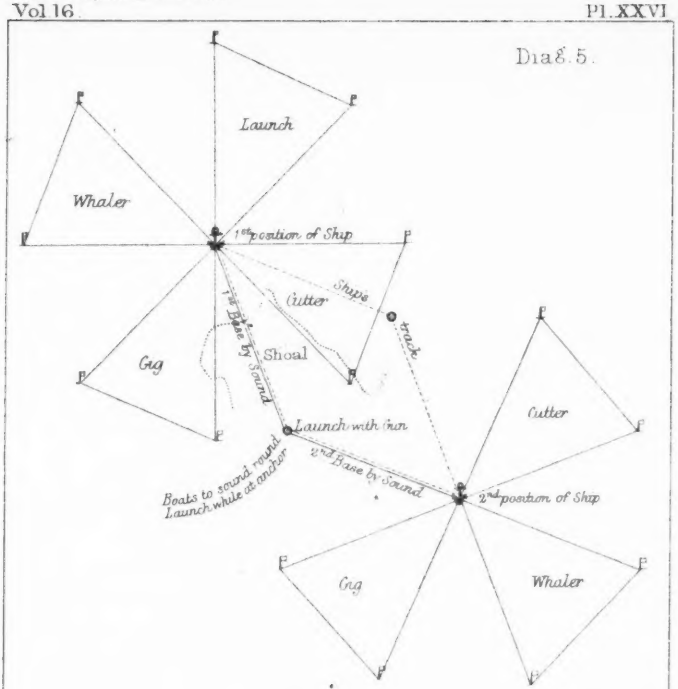
Shoals out of sight of Land.—If a shoal is fallen in with out of sight of land, or if a ship is sent to search for and examine a danger so placed, the vessel should, on finding the shoal water, if possible, anchor, mooring if convenient. Four boats might then be sent away to sound on north, east, south, and west lines from the ship for three miles, hoisting a flag every half hour, and taking a mast-head angle of the foremast, at which truck a black ball should be shown; an observer at the ship at the same time taking a bearing of the boat. (See Diagram 5.) At the end of the three miles distance, to be determined by mast-head angle, the boats will pull respectively E.S.E., S.S.W., W.N.W., and N.N.E. for $2\frac{1}{3}$ miles, fixing their position by mast-head angle, and hoisting their flags to allow the ship to obtain bearings of them. They will then return to the ship on S.W., N.W., N.E., and S.E. courses, sounding and hoisting their flags as before.

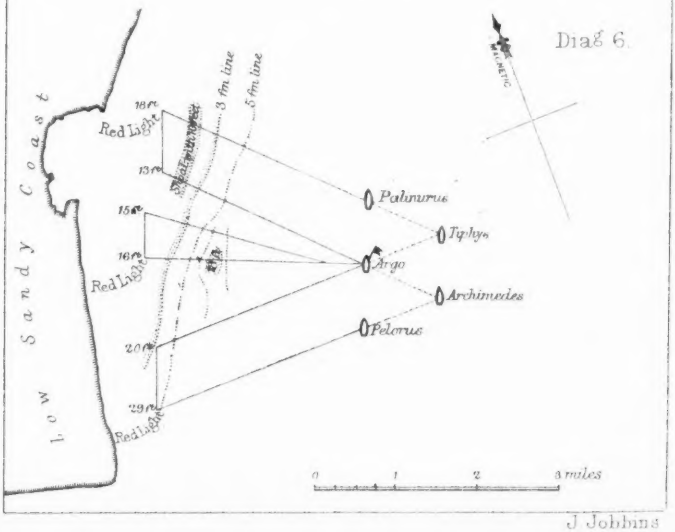
If shoaler water be found, requiring further or more extended examination, the launch, with her gun, should be sent in the direction of the foul ground to anchor on a given bearing at a distance of not over three miles from the ship; three guns will then be fired from both ship and launch to determine the distance. Ship will then weigh and take up a second position as convenient not more than three miles from the launch, when another base will be measured by sound, the ship beginning to fire when she has anchored. Launch will return to ship sounding, and the three remaining boats sound round the ship as before.

Coast Survey for Practice.—Sailing along a coast of which there are reliable charts, it is good practice to take angles, bearings, and true bearings, whenever observations are obtained, thus acquiring experience in examining a coast of which the charts are faulty.

Thus a true bearing from amplitude may be obtained at sunrise, with angles to conspicuous objects, noting the direction of the ship's head, the course to be steered, the patent log if in use, and the time. Another set of angles to the points taken at sunrise, and true bearing from azimuth, may be taken when the forenoon observations are obtained, other objects ahead being selected to continue the work by; a third set may be taken at noon, and the observations continued on similar principles in the afternoon and evening. Bearings of all objects in transit should be taken, and the direction of the ship's head and her courses carefully noted. If no current has been experienced, the courses steered and distances run, will form bases from which an attempt at projection may be made; or from the true positions determined by observation, the bearings and angles may be laid off, thus seeing how nearly conspicuous points could be recognized, and compared with the same points as marked on the chart.

Night Survey.—A knowledge of the system of sounding will enable an Officer under cover of the night, with the judicious use of masked


Diag. 5.
Launch
Whaler
1st position of Ship
Cutter
Ships track
1st Base by Sound
Shoal
Gig
Launch with Gun
2nd Base by Sound
Boats to sound round Launch while at anchor
2nd position of Ship
Cutter
Gig
Whaler


Diag 6.
Low Sandy Coast
Red Light
Red Light
Red Light
3 fm line
5 fm line
Palinurus
Tiphys
Argo
Archimedes
Pelorus
0 1 2 3 miles

J Johbins

lanthorns, to examine an enemy's coast, the charts of which may not be trustworthy, with a view of effecting a landing, of bombarding, or of otherwise giving him trouble.

In Diagram No. 6 a squadron of five vessels, viz., the "Argo," carrying the broad pendant of the Commodore, the "Tiphys," the "Palinurus," the "Pelorus," and the "Archimedes," are supposed to have anchored about four miles distant from the coast, on the following bearings and distances from the flag-ship:—the "Tiphys" east 10 cables, the "Palinurus" N.N.E. $7\frac{1}{2}$ cables, the "Pelorus" S.S.W. $7\frac{1}{2}$ cables, and the "Archimedes" S.E. 10 cables.

Immediately on anchoring, observations are made to determine the state of the tide, its velocity, time of turning, &c. The distance of the shore is found by observing angles from the "Pelorus," "Palinurus," and flag-ship, to well-defined objects on the shore, the distances the outer vessels are from each other affording a base, the same base to be measured by sound or mast head angles.*

As soon as it is dark, three boats will leave the squadron with muffled oars and other cat-like and cautious contrivances, one from the flag-ship, the two others from the "Palinurus" and "Pelorus." Each boat will be provided with the red bow-light of her steam launch,† a patent-log (the box part being lashed to the gunwale of the boat to allow of the hands being seen, the fly line being lengthened if necessary), watch, compass, lead-line, and sextant. The boat of the "Palinurus" will pull in N.W. $2\frac{3}{4}$ miles *over the ground*, keeping the lights of the "Palinurus" and "Tiphys" in transit, sounding continually, and allowing in her distance for the tide that may be running, the distance actually to be pulled being approximately determined on board the ship before leaving; the Officer in charge being required to exercise his judgment in the matter, as he will know approximately by the angle with her course, on which the boat has to be steered, to ensure her keeping the lights in line, the velocity with which the tide may be running.

On reaching her station, the boat will exhibit the light towards the flag-ship, carefully masked from the shore by jackets and other appliances, remaining in this station no longer than ten minutes.

While in this position the Officer in the boat will take bearings of the flag-ship and the "Pelorus," and if possible obtain the angle by sextant between the latter ship and the "Palinurus," avoiding the danger of reading off by stowing the sextant away with the arc firmly clamped, noting the time of arriving and leaving with care, keeping the boat in position by watching the lead.

The boat will then pull three-quarters of a mile S.S.W., or until the "Archimedes" comes in line with the flag-ship bearing S.E., when she will come back on that line sounding all the way. When sounding

* As this base may be considered small, the "Tiphys" and "Archimedes" might at first take up positions of respectively N.E. by N., and S. by W., distant two miles from the flag-ship, observers from the flag-ship visiting each vessel to obtain angles to objects previously determined upon; that done, and the bases measured, the ships would take up the positions originally assigned to them.

† Here, perhaps, Captain Colomb's inventions may be turned to useful account.

in-shore it may be advisable to stop the boats to sound, thereby avoiding the splash of the lead.

The boat of the "Pelorus" will pull in west $2\frac{3}{4}$ miles on similar principles, keeping the "Archimedes" and "Pelorus" in line; arrived at her station she will exhibit her light, obtain bearings of the flag-ship and "Palinurus," measuring the angle between the "Pelorus" and the latter ship, remain in station ten minutes, noting time of arrival and leaving with care. She will then pull N.N.E. three-quarters of a mile, or until the flag-ship comes in line with the "Tiphys," bearing east, when she will pull to the flag-ship on that line, sounding the whole way.

The flag-ship's boat will pull in W.N.W. $2\frac{3}{4}$ miles, keeping the "Argo" as near as possible exactly between the "Tiphys" and "Archimedes," arrived at her station she will exhibit her light and obtain angles on the same plan as the other boats, she will then pull half a mile N.N.E., and then S.E. by E. for the "Archimedes," keeping that ship just open southward of the "Argo" until close to the flag-ship, sounding the whole way.

Meanwhile the ships on the departure of the boats will, on a signal from the flag-ship, all hoist position lights, as if in communication with friends in the offing. A sharp look-out will be kept from the "Palinurus" for the boat of "Pelorus" showing her light, and *vice versâ*. Directly the lights are seen a bearing will be taken, and, if possible, angles measured between the boats and the flag-ship. A second look-out will be kept for the light of the flag-ship's boat, and also for that of their own boat; angles and bearings taken, and the time in all cases particularly noted.

These angles and bearings will at once be sent to the flag-ship, from which ship angles and bearings will be taken to the boats on similar principles.

Taking it for granted that this manœuvre is successfully executed, the following information will be obtained:—That the 5 fathoms line lies about three-quarters of a mile from the shore west of the "Pelorus," and $1\frac{3}{4}$ mile from the shore north-west of the "Palinurus;" that there is a distance of about one-third of a mile between the 3- and 5-fathom lines: that a shoal distant $1\frac{1}{2}$ mile from the shore lies 2 miles W.N.W. of the flag-ship, on which as little as 18 feet was found, while the northern boat found a ridge of 10 feet little over one mile from the shore. The general result of the examination has shown that foul ground lies to the northward, but that the southern part of the coast appears to be clear.

The squadron might then weigh, and taking a new position to the southward, in a similar manner renew the examination.

It may be remarked that this work could be done without the risk of exhibiting lights from the boats. The answer is the uncertainty of even practised men being able with any tide running to take their allotted positions; the difficulty of getting angles and bearings from the boats; while the bearings from the ships ensure a greater amount of accuracy in the work. Masked lights have been used with success and may be so again.

Advantage may be taken in the day time to observe from the ships the nature of the country, angles may be taken which, combined with others obtained immediately on landing, will serve to fix any elevated points, forts, or bridges. Angles of elevation to any heights may be taken and worked out, and thus some knowledge of the prominent features may be put upon paper, and prove of great assistance to the Officer in command.

For many of the practical hints contained in this paper I have been indebted to the kindness of Captain Shortland and other friends whom I have consulted on the subject, and I am free to confess that I have thereby added considerably to my own knowledge of "Practical Nautical Surveying." Admiral Ryder has also suggested the following ideas relating to the survey of an enemy's coast by night.

Steam launches may be used to run the lines of soundings, and with great advantage, owing to the speed with which they can run in, return, and escape if chased; the assumed difficulty of keeping the lead-line clear of the screws may be overcome by having a metal open framework fitted in front of, and on each side of the screw, or towing a boat alongside, from which the casts of the lead should be made.

Electric Light.—The power of throwing a beam of light, sufficiently brilliant to light up fully a ship two miles off, can, it is said, be obtained by means of the electric light. This may evidently be made very useful in aiding a night survey. Small fast steam vessels sent in on the flanks could frequently illuminate the beach and water near it, passing the beams slowly or quickly as may be thought advisable; this would draw the attention of the enemy from the surveying boats which would be pushed on in the dark space between the flank ships and between beams of light thrown by those ships on the beach.

Marking Extreme Positions.—Each boat should drop an anchor and beacon-buoy at her extreme position, which should be fixed by cross-bearings from the ships immediately after daylight, before the enemy has time to remove it.

Exercise in making Night Surveys.—The only way to ensure our being able to make useful night surveys in war time, is to practise in peace time, first by day, and then by night. The boats from ships at Spithead could be usefully exercised at making a night survey of the anchorage off Southsea Beach and the Isle of Wight, and from ships in the Sound, of Drake's Island and the beach under Mount Edgecumbe.

Signals.—The flashing signals should be used when necessary, but very sparingly, from the boats. Each boat should have a general and a special pass word.

The Colour of the Boats.—This should be light grey, to be as little distinguishable as possible.

I would remark in conclusion that although nautical surveying, from its simplicity, may seem suited to the meanest capacity, still, if real success be looked for, there is no profession that requires more straightforward perseverance and steady application. It is adapted not so much to "men of genius" as to those who possess the rare gift of industry

in one particular direction, or what Carlyle calls a capacity for taking trouble, with conscientious labour, shirking and evading no difficulty, completeness of work in all its divisions, and incessant practice when opportunities offer.

I have thus, Sir, in as full a manner as the time at my disposal permitted, endeavoured to embody in my lecture the programme of the Committee of this Institution on "Practical Nautical Surveying." To fulfil the wishes expressed in the last clause of this instruction, viz., "To ensure at some future time our having on board every ship of war "one or more Officers capable at an instant's notice of undertaking a "rough marine survey," is, however, beyond my powers; with the active co-operation of the State it may nevertheless be accomplished.

We possess gunnery establishments and go to vast trouble and expense in raising a body of Officers cunning in the manipulation of the huge artillery of the day, but unable, from pressure in one direction, to give much attention to the art of navigating the wondrous platforms that carry that artillery.

The science of naval gunnery, however perfect, cannot be turned to account, without the assistance of navigation, to guide our floating batteries with confidence and security.

This fact strongly points to the necessity of extending to navigation and nautical surveying a care and encouragement similar to that which naval gunnery has so long enjoyed.

If this could be done, and a system established by which the subjects briefly treated upon in this paper could be fairly and practically taught, it would in a few years "ensure our having on board every man of war "one or more Officers capable, at an instant's notice," not only "of "undertaking a rough marine survey," but qualified to perform in their various branches the responsible duties of the pilots of the Fleet; able, as of old, to place an element of success at the disposal of the fortunate Admiral or Captain under whom they might have the honour to serve.

Evening Meeting.

Monday, 1st July, 1872.

COLONEL DUNCAN J. BAILLIE, Commanding Royal Horse Guards, in the Chair.

NAMES of MEMBERS who joined the Institution between the 25th June and 1st July, 1872.

LIFE.

Clerk, Godfrey, Lt.-Colonel Rifle Brigade. 1*l.*

ANNUAL.

Bunbury, Chas. Thos., Capt. Rifle Brig. Acland, C. T. Dyke, Lt. 1st Devon Vols.

THE BREEDING OF HORSES FOR MILITARY PURPOSES.

By Captain H. M. HOZIER, Assistant-Controller, Aldershot.

IT would be as useless, as it would be impossible, to attempt to describe the necessity for military purposes of maintaining a good breed of horses in a country. The fact of the necessity of the horse in war has been recognised from the earliest times, and as military science has advanced, the value of the horse in the theatre of war has been more and more appreciated. Larger numbers of horses have constantly been required in each successive campaign. It is true, indeed, that in the present day the bulk of the forces brought into actual conflict on the field of battle does not consist of mounted men at arms supported by a few foot soldiers as in the middle ages, and some enthusiasts, till the last war in France proved the fallacy of their views, actually insisted that arms of precision had driven cavalry off the field of battle altogether. Experience, however, has proved, what common sense prognosticated, that the introduction of arms of precision, both directly and indirectly, has increased the necessity of the horse for military purposes.

In the first place, the introduction of a rifled armament has necessitated a much wider field of observation and of scouting than before. A much greater extent of country must be embraced by the vedettes and outposts, both in front and flank of an army, than formerly. The movements of masses of troops, and the concentration of armies must

be more carefully shrouded than of old, for now-a-days movements, when once matured, cannot readily be checked or altered, and must be carried through. A great portion of the success of the Prussians in the earlier days of the late campaign was due to the surprise with which their heavy columns burst upon the unsuspecting French. These columns had been concentrated secretly, and, during their concentration, had been entirely shrouded from the observation of the French purely by the wide screen of posts and deep curtain of vedettes thrown in front of the Prussian infantry by the Prussian cavalry. This cavalry not only entirely concealed the movements of its own armies, but, through the advantage of its numbers and organization, ferreted out and reported to its Staff every movement of the enemy.

In the second place, the introduction of arms of precision has increased the distance between the lines of battle, even in actual conflict, and the rolling of the intermediate ground affords favourable opportunity for the action of cavalry even on the field of battle. That this action of cavalry, however, much previously scouted in theory, is still of the highest importance, may be seen from the very latest experience; for at the battle of Vionville, Prince Frederick Charles, although he had only 24,000 infantry, saved the day, and prevented the passage of Marshal Bazaine and 180,000 men by the skilful use of 19 regiments of cavalry. The wide extent of ground covered by modern armies in battle affords favourable points of concealment for bodies of cavalry, whence they may dash suddenly on unsuspecting batteries or isolated skirmishers.

Again, armies now operate in much larger numbers and at much greater distances from their base of operations. Their trains of supply and stores must be much heavier than of yore, and would astonish a Turenne or a Marlborough. The introduction of breech-loading armament has greatly increased the necessary supply of ammunition, and this ammunition must be supplied by horse power on the very field of battle at the moment required. Horses must also be ready to remove the largely-increased numbers of wounded beyond the further reach of fire.

We may thus gather that the number of horses required in war will continue to increase instead of diminishing; and we can also see that broadly the horses required in war may be classed under four heads:—

1. The horse required to be ridden to collect intelligence, convey reports, and do the various duties which form the functions of light cavalry.

2. The horse which requires to be ridden and take prominent part in the actual crash of the charge, and is retained chiefly for the duties of heavy cavalry.

3. The horse required for draught and yet active enough to manœuvre, and to follow troops at a trot, or even a gallop. Such are the horses which draw the guns, the ammunition carts, the ambulances, and the first reserve of ammunition.

4. The horses which are required to trail along the long lines of communication in rear of the army; to bring up to the supply depôts the constant flow of food and stores, without which being

properly assured, the Army cannot live a day, advance a mile, or fight an hour.

For breeding purposes these might be further classified. The horse of the light cavalry and heavy cavalry may be regarded as one, for the lighter could be told off to the light, the stouter to the heavy cavalry. But the horse of the artillery and train should be kept distinct.

It seems a great error that this is not the case, as the train is generally horsed much too slightly. The horses required for train purposes ought to be great heavy dray horses, of the type of the Clydesdale cart-horse, the Suffolk Punch, or the heavy horses in brewer's drays, instead of as at present merely coarse imitations of cavalry chargers. One heavy horse would do as much work as two of the present train horses; would require half the attendance and only eat three-fourths as much.

It is very difficult to estimate the number of horses of these different kinds which our Army would require in time of war, because it is impossible to say how many troops would be put into the field. It may be, however, presumed that in case of that invasion, the fear of which alone ever induces any progress in military matters in this country, out of the regular Army at home, Militia and Volunteers, we should at least place 100,000 men in the field.

The cavalry to accompany these should be in the proportion of at least 1 to 20, or 5,000; the artillery 3 guns to 1,000, would require 300 guns or 30 batteries, of which 10 should be horse.

The light train required would be 25,000 horses, and the heavy train would require with reserves, &c., 75,000.

Cavalry—10 regiments, 500 strong, present establishment being 350 each, would require 150, or—

1,500	horses.
5,000	artillery.
25,000	light train.
75,000	heavy train.
106,500	Total.

Now the total number of horses in the country is theoretically 2,150,000, including old horses, foals, brood mares, &c. If these range from foals to 15 years old, we have an average of 143,000 of each age, or 572,000 horses between four and eight. If we had power to take all horses at once, we should be in no difficulty, but we have not the power, and if we had, it would be impossible to exert it. Fancy London, Birmingham, &c., with their horses taken away! Whole populations would starve, trade would be paralysed, and we should be actually playing the very game of the enemy.

It would be impossible to seize the whole of the available horses in the country without warning; it would be a different thing if we registered horses during peace, and told the owners we should want them in war, as in Prussia. Then owners could make their arrangements to be ready at the hour of need.

But it is doubtful, notwithstanding statistics, even if we could seize

all the horses, if we should get the numbers quoted above. Nothing is so fallacious as figures, and the real practical test of the *quantity* of horses we can get is the facility of supply.

As to quality, last year for the manœuvres we had to buy 1,038 old horses avowedly only for a few weeks' work, and had to pay £38 a piece for them.

This year we are again buying about 2,000 at, I believe, £42, as well as £1 to £2 for travelling expenses.

It has been urged that the horses could have been procured young abroad, and after being kept for two months on Government forage, sold at a profit; but the Continent would be closed in time of war, or at least there would not be time to get the horses over, and it was wise of the Government, if solely from question of experiment, to determine to draw all the horses required from the horse market.

We can now see sufficiently well, that it is most difficult to get 2,000 horses in time of peace of serviceable condition, and we may confidently predict it would be impossible to find, at the sudden outbreak of a war, the 100,000 which we have seen above would be necessary for military purposes.

The worst feature of the case is, that instead of there being any prospect of improvement, both statistics and facts for once agree, and show that matters are rapidly getting worse. We see that this year we find more difficulty in getting horses than last year; we know that the prices of remounts have had to be raised, and we know from every good authority that horses are daily, and will become daily more difficult to obtain. The causes of this diminution of horses seem not difficult to perceive.

1. Prices offered in the foreign market have tempted breeders to part with their mares. In Ireland the action of the Encumbered Estates Court, by throwing the formerly small holdings into larger farms, has greatly diminished the number of mare owners and consequently of foals.

2. The breeding of the heavy cart horse which, on our present system, is not available as a military horse, pays the farmer better, as it can be worked at two years old on the farm, and is less liable to disease and accident by galloping about against fences, &c., than the more active and highly-bred horse.

3. The large exportation of the country.

4. The tendency of purchasers, especially the Government, to deal with middlemen and contractors instead of with breeders direct; a course which diminishes the breeder's profit.

Whether, however, these be the true reasons or not, the acknowledged dearth of horses makes it necessary that some measures should be taken to obtain a ready supply of horses in case of war.

Foreign countries have long recognized this. France distributed horses among the farmers in time of peace, which were to be called up in case of war; but this system at the outbreak of the last war was found not to answer.

Prussia established large studs, and also possesses the power of seizing a certain number of horses at fixed prices from each part of the

country. This system in Prussia is not so dangerous as it would be in England, for Prussia is a country mainly agricultural; and in time of war agricultural operations are naturally delayed.

Till lately we had an excellent breed of horses in England. From early days the rulers of the country had devoted attention to the subject, and the climate seems naturally to have been suited to facilitate their endeavours.

In the reign of Henry the First, the first Arabian horse on record was introduced into this island by Alexander, King of Scotland, and was presented to a church; and in the reign of Henry the Second, Smithfield was already famous for the racing there of hackneys and charging steeds against each other.

John imported 100 heavy Flemish stallions, the distant sires of our now famous Clydesdales and Suffolk Punches.

Many Kings imported horses, but it was in the reigns of Charles the Second and William the Third, that the great horses, which may be regarded as the patriarchs of our present thoroughbred racehorses, were brought to this country. These were the Godolphin Arab, the Darley Arabian, and the Byerley Turk; and the blood of some one, or all of these, beats in the pulse of every horse now on the turf.

From the Byerley Turk, have sprung in direct male descent Hobbie Noble, Thormanby, Bay Middleton, Flying Dutchman, Parmesan, Caractacus, and Buccaneer.

From the Darley Arabian, in direct male descent, Touchstone, Orlando, Marsyas, Cotherstone, Lord of the Isles, Dundee, Gladiateur, Stockwell, St. Albans, Lord Lyon, Voltigeur, Weatherbit, Beadsman, and Blue Gown.

From the Godolphin, the Melbournes and West Australians.

For reasons into which it would be here tedious to enquire, it is my opinion that the more the blood of the Darley Arabian is concentrated in a horse the better he will be for what is technically called staying purposes.

Now the crucial question is, What measures are we to take to preserve, or perhaps how to improve, the quality of the breed and increase the quantity of horses available for military purposes?

We might—

(1.) Prevent exportation of all horses. This method would be clumsy and contrary to the spirit of the times, unfair to the landowner and farmer, and extremely impolitic.

(2.) Prevent exportation of mares. To this plan there are of course similar objections to the former.

(3.) We might form Government studs. This might meet the difficulty to a limited degree, but the expense would forbid all the horses we require being bred in this way.

(4.) We should certainly encourage breeders of all descriptions by dealing directly with them, and not allow a monopoly of the whole trade to fall into the hands of a few contractors.

(5.) We have seen that the horses required for the train constitute the great proportion of the horses which would be needed at the outbreak of the war. These could easily be procured at moderate

cost, provided that we would only recognize that for train purposes, we should have cart horses instead of imitations of bad cavalry chargers.

Were this so, Clydesdale or Suffolk stallions might be located in the various districts of the country and open to free use by the farmers, provided that the stock were liable to be taken in case of war by the Government at a fixed price. Of course one agreement would be, that none of this stock should be sold to go abroad. Farmers would gladly consent. There are believed to be about 250,000 cart mares in England. It is probable that as a cart mare can do her farm work till within a few days of foaling, at least 100,000 of these should foal every year, and give the Government an available annual contingent of 100,000 draught horses; at the same time mares cast from the Government service, should be sold at merely nominal sums in the market towns, so as to fall into the hands of farmers—not cab-drivers—and be available for breeding. The *light* horses got by the local cart stallions would be available for the light train, perhaps even for the cavalry; the *heavy* ones for the heavy train. Stallions should be shifted from district to district every two or three years to prevent the same strain of blood being consolidated in any one district, and to provide that the species should not be deteriorated by in-breeding.

Having seen how the train horse might be procured, let us now turn to the cavalry horse. Speaking from a breeder's point of view, the horse for the heavy cavalry is the same as that for the light cavalry, for the former would only be the heavier selected from the young stock. It is my firm impression (though I believe it will be regarded as rank heresy by many cavalry Officers) that there is nothing equal to the thoroughbred blood horse, provided the thoroughbred horse has bone and substance. A good blood horse has more bone and substance than good half-breds. This can be amply demonstrated by weighing similar sections of the bones of each. People accustomed to see young thoroughbreds of two or three years old on the race-course in racing condition condemn them as weeds; but what would half-breds look like in similar conditions? It is not fair to compare the three-year old in racing condition with the pampered troop horse of eight or nine summers rolling in fat and only exercised at watering order. The way to see the thoroughbred as compared with the half-bred, is to visit some of the stud farms, such as Hampton Court, and see a furnished mare or stallion six or seven years old. It is such as these that we should wish to have as chargers for our cavalry. They would do more work, stand more fatigue, and exist on less food than any half-breds; but unfortunately the expense prevents us from getting them. We can only approach as nearly as possible. To do so we might place a certain number of thoroughbred stallions in different parts of the country for the use of country gentlemen, to whom for the cavalry horse we must look more than to the farmer; and maintain the right of having the stock at an assessed price in time of war. These sires should be obtained from the best stock of the country, and should contain as much Darley Arabian blood as possible.

But to maintain the sires that we should want, and also to obtain the

horses we should wish, there ought to be at least one or two Government studs. At the present moment many good horses, such as Paganini, could be bought moderately from the turf and would act as sires; but it appears as if we could not long trust to the turf. It is impossible to deny that some excellent horses are still on the turf, perhaps a few as good horses as ever were on the turf are now in training; but the general average is deteriorating. The prevalence of short races and handicaps allows worthless horses to be retained in training which become sires and still worse dams; and although a few horses can stay well, the Queen's plates are nearly now always carried away by one French gentleman, M. Lefèvre. The Legislature might interfere here usefully. Nearly all the horses that can stay in England belong to the foreigner, M. Lefèvre. If the best thoroughbred *class* deteriorate, so must our sires deteriorate.

It would be advisable to have studs for sires, as it is very difficult to buy good sires, except at enormous sums, when once exposed on the turf. Yearlings might be sold on condition of being returned at the end of their racing career.

All good mares should be covered gratis at the Government studs, and stock liable to be taken only in case of war.

I have endeavoured to explain the ideas I have formed. They can only claim to have been carefully considered and not crudely enunciated. It will be a great pleasure to me if they may lead to a discussion and consideration of a subject which seems to me to be so very important to the nation in general and to the Army in particular.

The Earl CATHCART: I do not know, whether I, as a stranger, am entitled to say anything on this occasion. If I were allowed to do so, I would merely wish to say a very few words, to show how anxious we farmers are to co-operate in any possible way. As a member of the Council of the Royal Agricultural Society, I may say we have already taken great interest in the subject now in question. I have given my best attention to every thing that has been said by the able and gallant lecturer. Although I was prepared to hear a most able lecture from a gentleman of his great reputation, I must say that I was not prepared for the comprehensiveness, the ability and research which this lecture embodies. We farmers can agree in a great deal that has been said by the gallant lecturer. I am sorry that circumstances did not allow me to take notes, as I would gladly have followed the lecturer throughout his lecture. I venture to think he has scarcely given sufficient importance to two points. Firstly, there are great numbers of horses retained in this country for the purposes of luxury. These horses in case of war are all available. And in a military point of view we must not forget the steam-horse, because, you know, our friends the Prussians at Paris had the steam-horse, which they found exceedingly useful. I have no doubt from all I see of steam traction and cultivation, that we shall see the steam-horse day by day more and more employed. I have watched him, not from his earliest infancy, but for the last eight or nine years, and I see him making wonderful progress. As regards the inducements to farmers to breed horses, by reason of the Government supplying stallions throughout the country, really as far as agriculture is concerned, we have many stallions, and really good ones. I doubt whether the Government offer would be a great inducement. As to purchases by middle men, I incline to agree in thinking it would be an advantage if Government were to go more into the market and buy for themselves. Referring to the lecturer's observations as to the use of cart horses for guns of position and military train purposes, I entirely agree with him. I know from my own experience that the thoroughbred cart horse is a better animal than the coach-horsy cart horse. The real cart horse keeps his condition better on the same food, throwing his weight also into the collar. I believe

the Clydesdale to be the most valuable cart horse that we have. I have heard the origin of the Clydesdale horse was this:—A Duke of Hamilton, about 200 years ago, brought over a number of Flanders mares for his carriage; they were crossed with the horses of the district. I do not know at what period the Suffolk Punches were first bred, but I have no doubt that they have a Flanders origin. On the whole, and regarding our subject generally, I am inclined to think that we must rely for our supply of military horses upon the general law of supply and demand. But we must always remember there is a certain Chancellor of the Exchequer who knows all about the horses of the country; and whoever may be Chancellor of the Exchequer, he invariably lays a heavy hand on the horses, and thereby to some extent discourages horse keeping and horse breeding. Why, a man for a consideration dare not give another a lift on the road, for he does not know whether the stranger may or may not be a tax-gatherer. In conclusion, I would say again—the object of my speech—that the Royal Agricultural Society of England took this matter up. Some time ago, I myself got the principal veterinary surgeon of the Army to write a paper on the supply of horses for the Army, which paper was published in our Journal, and when in print we shall be glad to study Captain Hozier's able lecture, and to give it our best consideration. We civilians thank you for this opportunity of stating our opinions, and to the gallant lecturer our warmest acknowledgments are justly due and heartily accorded.

The CHAIRMAN: I think we are very much indebted to Captain Hozier for the able lecture he has given us, on a subject which is very important, not only to military men, but to the whole country, because England has from time immemorial been celebrated for horses and for riders, and I should think there are very few in this country who would wish her to lose her name for having the best horses and best riders in the world. I am afraid our class of horses are depreciating very much. For a very long time the mares have been going out of this country, and there has been an increased difficulty every year in procuring horses for military purposes, and for every other purpose, too. The difference of price tests the number of horses there are in the country. Just before the Crimean war, the horse artillery used to give thirty guineas for their horses, and the cavalry twenty-five guineas. Now the horse artillery give forty-five guineas, and the cavalry forty guineas. The artillery certainly are supposed to have four years old, and the cavalry also are supposed to have four years old; but they take them as four years old on the 1st of October, which is really three-and-a-half years old; so that there is very little difference there. During the last two years the General Omnibus Company have increased the price they give for their horses by £10. The price of the different horses employed on the tramways, in omnibuses, and railway vans has risen to an enormous extent, so much so that cart horses in a great part of the country are fetching £100 a piece. It seems an enormous price for a cart horse, but the price can be got as easily as possible now. We expect to get draught horses for our artillery and for draught purposes at the autumn manœuvres with the greatest facility, we imagine that we are to send out an order for two thousand horses, and we shall get them directly, but you cannot do that if you allow the mares to go out of this country. In a country like ours it is very important to keep up the breed of horses, not only for military, but for every other purpose, from racing and fox hunting down to *polo*, or any amusement you like to employ them at. I will not say, "down to *polo*," because I think it is a good game to teach young men how to ride; it is only on ponies; and the game is not very well known, but still it is a very good game. I do not quite agree with Captain Hozier on one point. He says he does not think it is necessary to consider the cause of the mares going out of the country. I do, because I think that is the cause of the whole evil. The cause of mares going out of this country is, simply, as far as I understand it, that there is not encouragement enough given to farmers to keep these mares. You must trust to your farmers. I do not believe that any breeding stud in the world will supply us with the number of horses that we want in this country. You want the farmers to supply you with horses, and for that they must keep their mares. Now what happens? In the last twenty years the coaches have been given up. The farmer has not been able to sell a horse he did not want to the nearest coach for a leader or wheel horse, or for any of those employments that were open to them then. The only chance they have of selling horses for light employ-

ments is to omnibus proprietors in connection with the nearest railway station. Then the question for the farmer is, "Which pays me most; a horse or a bullock?" I have been farming for some time now in a small way, although my military duties have taken me away so much that I could not attend to it properly (I live in Scotland); but I know that a horse does not always give you a profit. Therefore, a farmer, unless he is encouraged, will not keep a horse. Now, the only plan which has ever seemed to me practicable in the way of encouraging farmers to keep horses, is to do away with the Queen's plates that are given for racing, and to employ the money as prizes at agricultural shows in each county. The Queen's plates are now useless as an encouragement to improve the breed of race-horses, because it is not the best class of animals that compete for these cups. Let a prize be given for the best stallion, which shall remain in the county or district (whichever the Government, or those whom they employ, shall think best), and cover the mares of the farmers who belong to the county club or association, at the small fee of two guineas, and something for the groom; the stallion not to be allowed to go out of the county or district on any consideration for that year. If you give this money in prizes, there is a chance of people being induced to bring the best stallions into the county. We have got plenty of good stallions in the country; they go to agricultural shows, they win a prize, but they are bought by the foreigner, and they go abroad. If Government could give such prizes as I have indicated, it would make it worth while to people to bring their stallions to the shows, on the condition that they should serve the mares of the farmers during the year, and they might have a testimonial, or whatever you choose to call it, to say that the horse has won a Government prize. I believe this plan would be a great encouragement to farmers to keep their mares; and persons who, perhaps, are not farmers, people in a small way, who have got a mare which they use for their own dog cart, would take their mares to the stallion to be covered; they would not only know that they were going to a horse that had won a prize, but a horse that had got the Government mark upon it, or the proof that it had won a Government prize. I believe if that were done you might give sufficient encouragement to farmers to keep their mares in the county and to breed horses. I do not believe in Government s' ids. A Government stud might provide a few stallions to travel about, but it could not possibly provide mares or horses, the expense would be too great. With the cups that are given for racing purposes, I believe you might cover the whole expense. At all events, this is the idea that I have formed on the subject, and I believe it to be the only practicable course. I think we ought to have the best horses in the world. Foreign nations have been sending over here trying to get the best blood out of the country. But I do not believe that any country can compete with us, because they have not got the feeding. The very soil makes as much difference in the production of horses as it does in the production of crops. You know perfectly well that you cannot get the same crop in every ground, and you cannot get the same horse on every ground. We have proved in Yorkshire, in Lincolnshire, and in Ireland, that the soils there suit horses, and there are other parts of England as well; but it is chiefly in those districts that you can breed horses. There is no other country in the world that can breed horses in the same way. Climate and soil have as much to do with the breeding of horses as with other things, including, of course, care and management. I beg to thank Captain Hozier again for bringing this important subject before us.

Colonel BAKER, 10th Hussars: I am sure we all owe our best thanks to Captain Hozier for the very able, impartial, and accurate way in which he has brought this subject before the meeting. It is one of the greatest possible importance to every branch of the service, and it is one also which is open to very great controversy. I think that in dealing with it, we should first consider how the evil which Captain Hozier has placed before us has arisen, and next how that evil may be best met. I think it would be found on inquiry that it has arisen from three causes. First, from the increase of riches in this country, which has created a greater demand for horses; secondly, by the exportation of a very large number of horses to meet the demands of foreign countries, and those demands have been very great of late years. That evil has been very much increased by the exportation of a very large number of mares, in larger proportion than the number of horses. Thirdly, by what has been so well put before us by the gallant Chairman, the fact that it pays farmers better now

to breed cattle—the price of cattle having so enormously increased of late years—than it does to breed horses. It remains for us to consider how this evil can be met. I must say I am very glad that Captain Hozier in his lecture to-night touched so ably, not only upon the question of the breeding of horses, but upon the question of a reserve of horses for military purposes, for upon that question of a reserve lies the main point with which we, as soldiers, have principally to deal. With regard to the breeding of horses, I think we must give up as hopeless the idea of providing for the deficiency by means of Government studs. But there is no doubt that immense encouragement might be given to breeding by the means which have been laid before us by the gallant Chairman, and by other means which have been considered, and which probably will be laid before us hereafter. But with regard to the question of a reserve of horses for military purposes, we can consider that question without reference to the executive or the Government. It appears, as it must appear to any one who has gone into this question statistically, that the number of horses in this country is at present quite sufficient for any military requirements that would be likely to arise. But we have no control over the horses of this country. Captain Hozier has given you the statistics, and the difficulties which occurred last year when we attempted to put a small *corps d'armée* (or what would be considered abroad a small *corps d'armée*) into the field. I have had long conversations with different dealers and different breeders relative to this question, and they all agree that it would be impossible, even in cases of emergency, to provide anything like a sufficient number of horses to put a very small force into the field. I have asked a great many opinions from a great many dealers and breeders, and they all say that there is only one means by which that can be done, that is by a system of requisition. That is very unsatisfactory. With that difficulty staring us in the face, I think we owe Captain Hozier very great thanks for bringing the subject forward in this way, and so opening up a discussion which cannot fail to be useful. Having said so much, I will now touch upon the point how we may make the supply of horses which does exist, useful for military purposes. Supposing we give, as it has been advocated, every encouragement to breeders, why should we not have all the horses in the country registered? They should be registered as it is, because they are taxed. Why should we not have them registered and described? And if the country is not prepared for conscription or ballot, as regards the supply of men, still I think it ought to be prepared for the ballot or conscriptive system as regards horses whenever the actual emergency arose. If we had all the horses registered, and had the ballot amongst those horses which would be required for the different purposes of war, and if those horses, having been examined by proper veterinary authorities, remain so registered, then in case of war we should know exactly in each county where to put our hands upon the number of horses that we might require. If those horses so registered were exempted from taxation, it would be a slight boon to those who would have to give them up, but only to give them up at a fixed price in case of war. I need not say that the horses in this country vary very much in price. Horses of extreme value might be drawn by this conscriptive system or ballot, but as the country would not be prepared to pay for horses of that description in case of war, they would come out of the category of horses for military purposes. Therefore, we should only draw and keep on the register such horses as the country would be prepared to pay a certain price for, in case the emergency arose. I trust that the subject will not be dropped, but will lead to a discussion that will be of value.

Mr. T. Pain: I should like to say a word if I am not out of order. I imagine that this question is one of pounds, shillings, and pence from beginning to end. The noble lord who spoke after Captain Hozier, said it was a subject that the Royal Agricultural Society had taken up very deeply. I quite agree with his lordship that we have taken a great deal of interest in it, but we have been unable to arrive at any conclusion whatever upon the subject. I heard the gallant gentleman who has just sat down say, that it would be an excellent thing to have a sort of registration of the number of horses that were kept in this country, so that in case of war they should be called upon to be useful to the service. But I take it if any gentleman was in possession of a horse worth three or four hundred guineas, he would think it very hard that he should be called upon to give up that horse. (Colonel Baker: I

exclude them). But, then, the poor man who has got a horse of thirty-five guineas value would say that it was very hard that he should have to give up his horse, and the rich man be allowed to keep his. All these things I contend are a matter of pounds, shillings, and pence. One or two remarks have been made as to the breeding of horses. The gallant Chairman says it would be an excellent thing if we were to do away with the Queen's plates, and to have horses in the different counties which should be available for the service of farmers at one or two guineas a-head. That is a very good idea as to placing of stallions. Then there is another to follow afterwards. A farmer says, "I can go and use this horse at one or two guineas; I have a very good mare, and I shall put her to it." But he sits down over his churchwarden's pipe, and he begins to calculate the odds, and he arrives at this conclusion—"If I put my old mare to this horse at one or two guineas, when the foal arrives at the age of three years I may be unable to get twenty-five or thirty guineas for the horse. I have got a cow, I can put my cow to the bull, and in twelve month's time I can get a heifer that may be sold for seventeen or eighteen guineas." Now, the price of cattle has so much increased in the last eight or ten years that the farmer naturally feels that he must farm that which is most productive to him. (The CHAIRMAN: I did not say that the colt was to go to the Government. Let the farmer make what he likes out of it). Nor did I. His price as a three year old may be worth thirty-five guineas, but the farmer has got to get a customer for it. Then the colt may have the strangles, he may be a roarer, or he may become blind. But the heifer will be worth sixeeen or seventeen guineas in twelve months. A noble lord said to me the other day, "Pain, what can I do for the purpose of increasing the breed of horses? I should like to buy a stallion, and I should like to buy half-a-dozen good old-fashioned mares, that I would give to my farmers to induce them to breed." I said, "My lord, you may get the mares and you may get the stallion, and they will breed, perhaps; but you must do something more, you must give them a guarantee that when the animal is three years' old you will give him £35 for it, whatever it is. Then he will be induced to breed, but unless there is a certainty about it he will not breed horses, but he will breed a cow." You may endeavour to lay down theories as to the breeding of animals of any description, but it only comes to one thing, that is £ *s. d.* All these theories may be very good, but they are of no use when they are brought into practical work. I have one idea about the subject, a very poor one; it is this, that a stallion should be put into every county, that stallion to be the property of the Government; that that stallion should not be allowed to be put to any mare that has not hereditary soundness, and that Government should offer prizes to the amount of £50, not for stallions, but for the best three and two-year old foals bred from this mare. Then you will induce the farmers to breed, but you will not induce them to breed unless you can show that there is the prospect of certainty.

General Sir WILLIAM CODRINGTON: I should doubt very much whether the increase of price shows a scarcity of horses in the country. In every single thing in this country prices have risen, and unless the lecturer will be able to show that there are fewer horses at this moment in England than there were before the price was raised, I do not think the question of price tallies with his argument. As everything has risen in price, so Government may have to give more, as every gentleman has to give more for the horse that he wants to ride. Artillery horses are no exception, cavalry horses need be no exception to this result, therefore I should be glad to know if there is really any such scarcity, independent of the price as a test. I do not quite think price is a test of scarcity, because everything has risen. There is no doubt the whole question is one of pounds, shillings, and pence. If Government would choose to raise its price to fifty, sixty, seventy, or one hundred guineas, the Government would get the horse they wanted; there cannot be a doubt of that, for horses can be got by gentlemen who want to hunt, or by those who want to ride them as hacks. I believe the horses would come if the money was forthcoming. I do not say Government can afford to give those great prices, but horses can be had by paying for them, for, as I said before, it is quite a question of pounds, shillings, and pence. With regard to the registration of horses, there would be great difficulty with respect to it in a country like England. We should have to provide a large civil establishment for the purpose, and we know that civil establishments, interfer-

ing with the liberty of private arrangements, are not well looked upon in this country. I rather doubt the practicability of carrying out the proposal in England. You may be quite sure that if ever this country should want horses for military service, in case of invasion,—which it now seems is the main purpose for which an army is to be maintained,—it will not be a question whether you shall buy, you must have a temporary dictatorship with power to take horses when and where it is necessary.

Mr. PAIN: You must bear in mind that the value of the horse has very much increased of late. Horses are now, I should think, 33 per cent. dearer than they were four or five years ago. But there is this to be considered, that the wealth of the country is so much greater than it was, that more people keep horses, more men hunt, there is more luxury at the present moment than there has been for many years past. One observation which the noble lord made was of a practical character; it was this, that if you took off the tax upon horses, it would conduce to the improvement of the breed of horses, by enabling people to keep horses; you might as well tax a cow as tax a horse.

Sir W. CODRINGTON: To make another remark. The lecturer, Colonel Baker, and myself were at the establishment at Trakehnen, in one of the provinces of Prussia. Perhaps the lecturer will describe to what distance that establishment extended its ramifications in the provinces, whether the large establishment we saw there was merely for keeping a centralised establishment, or whether the stallions were sent round the different parts of the country. My impression is that they were so sent to cover mares in the different parts of the large province in which the establishment was situated. They leave the stock with the farmers, and I think the Government take them at their own price in consideration of the stallions being sent out free. If the lecturer could give us some explanation on that point it might be interesting to the meeting.

Earl CATHCART: There is one point of considerable importance which I omitted. I have read an admirable paper somewhere, I think it was in the *Révue des Deux Mondes*, on the recent use of railways in war. It was especially laid down by the Prussians that a railway in war in advancing an army, comparatively could be little depended upon. One objection was that it deteriorated the troops, that infantry carried by railway did not come up in such good fighting condition as those marched by road. Another objection was the want of expansibility. You want troops coming to the front to expand fan-like. I entirely agree with my friend (Mr. Pain) that the breeding of horses, as I said before, like most things in this country, depends upon the general law of supply and demand, or, as he puts it very tersely, on £ *s. d.*

Captain HOZIER: I believe Sir William Codrington is perfectly accurate with regard to the Prussian stud at Trakehnen. The stallions are sent round to the farmers in the province, and Government have a right to take the stock at a certain age and at a certain price. But I believe the Government stud at Trakehnen, as far as the horses actually within the walls are concerned, are not intended for military purposes, they are kept chiefly as sires to serve mares all through Germany. As to the question of a diminution of horses in this country, I am not prepared without book to give an opinion about that. I rather think the Board of Trade returns show that the supply of horses has actually diminished in this country to a small extent. If I remember right, within the last three or four years, this diminution seems to be at the rate of two or three hundred a year, whereas the number of horses ought to increase with the increase of population and wealth. (Sir W. CODRINGTON: That is the taxed horses?) I believe the returns are made of all horses. The thoroughbred horses have also decreased in numbers within the last two or three years. I believe the thoroughbred stock has considerably declined during the last two or three years. There is only one word more that I wish to say. The noble earl spoke about the use of the steam-horse in war. I hope he does not think we do not attend to that in our army, because we have had a traction-engine at Aldershot, and we find, as the Prussians have found, that it is very useful when an army has settled down for a siege; you can then use the traction-engine. But as long as an army is moving across country, over mountains, and where roads have been broken up and bridges destroyed by the enemy, then, for all practical purposes a traction-engine is useless.

Besides that, the traction-engine requires an enormous quantity of fuel to feed it, and it would be necessary to have almost as much transport for the engine as for its load.

The CHAIRMAN: We have to thank Captain Hozier for his valuable paper, and also the gentlemen who have favoured us with their observations.

Mr. WILLIAM WHITE, F.S.A., of 30A, Wimpole Street, exhibited and explained his Porte-Knapsack as follows:—

The Knapsack itself is like an ordinary waterpoof one, but is fitted with light stiffening canes, to allow of contraction in size, and of simplicity in the fastening of it.

The Porte-Knapsack has a very light frame, or yoke (*y*), to keep the bearing webs in *tension*. The whole of *the weight*, instead of dragging as usual from the *front* of the shoulders, *is carried upon the shoulders by these tension webs* (*t*), except what is distributed on to the back, by the back webs (*b*) resting gently against it. The webs should be buckled just tight enough, to keep the cane yoke (*y*), and the cross cane struts (*c*), at about the angle shown on sketch, when in use. If not tight enough, the Knapsack will have a tendency to slip off, if too tight, it will not fit pleasantly. The proper adjustment is when it will just lodge on the shoulders and back, without the aid of the fastening straps (*f*), which are required to keep the load from jolting off, but which still allow perfect freedom from strain and leverage. These

fasteners, fitted with the usual hook and eye (*h*), should be buckled as short as they will go, without being tight enough to *press* against the front of the shoulder. When not in use, the shoulder yoke and the cane cross struts may be kept folded close on to the back of the Knapsack, by passing these fasteners behind the tension webs and hooking them into each other. The small neck strap (*n*) should be tight enough only to keep the back of the cane yoke well off the neck of the wearer.

I have carried with the Knapsack over 20 lbs. weight without inconvenience, and I have carried, at the rate of more than four miles an hour, 15 lbs. with less strain than I could have carried 10 lbs. at a slower pace by the old mode.

Rejoicing as I have always done in the freedom and independence of Knapsack excursions, though fain to seek relief sometimes from the labour, and the langour, entailed by all previous methods of slinging the burden, through which multitudes of soldiers, especially young soldiers, as well as civilians, have suffered terribly, it is a pleasure to place within the reach of my friends (and of the public generally) a mode by which it may be carried without such inconvenience.

The Porte-Knapsack may be fitted to an ordinary Knapsack; but the expanding Knapsack which forms part of the same patent, and which is particularly simple in its arrangements, is specially suited to it.

In reply to a question, Mr. White stated that the weight of the apparatus was about 2 lbs. and a-half.

Evening Meeting.

Monday, July 8th, 1872.

Captain JASPER SELWYN, R.N., in the Chair.

NAMES OF MEMBERS who joined the Institution between the 2nd and 8th July, 1872.

LIFE.

Gordon, W. E. A., C.B., Captain R.N.
Hart, Horatio H., Lieut. R.E.
Fitzherbert, W. H. M., Lieut. Rifle Brigade.
Kenyon-Slaney, Walter R., Lieut. Rifle Brigade.

ANNUAL.

Elliot, A. F., M.D., Staff-Surgeon.

READ AND NICKOLL'S PATENT INDICATING DAY AND NIGHT HELM SIGNALS FOR PREVENTING COLLISIONS AT SEA.

By Mr. George Read, R.N.

I have the honour to bring before you this evening an invention for the prevention of "Collisions at Sea."

It is a subject which must enlist the attention and sympathy of every class of the community, whether it be the shipowner, the ship insurer, the merchant, the traveller, and last but not least, "poor Jack" himself, as all have a vital interest in this most important question.

The traffic on the ocean has become so great, the value of the merchandise so immense, the sailors employed, and the public who travel by sea so numerous, that every nation is not only interested, but is in duty bound to adopt such measures as may tend to lessen the loss of life and property by those fearful collisions, which are continually occurring, and to render voyages as free from danger as possible.

In order to convey an idea of the magnitude of the subject, I beg to call your attention to the last published returns of the Board of Trade, by which it will be seen that the total number of British vessels entered inwards in 1866, amounted to 33,393, equal to 10,692,102

tons; and in 1870, to 35,182, equal to 12,380,390 tons, showing an increase of 1,789 vessels, and an increase of 1,688,288 tons.

During the same years there were cleared outwards, viz., in 1866, 32,203 vessels equal to 10,563,624 tons, and in 1870, 35,405 vessels, equal to 12,691,790 tons, showing an increase of 3,202 vessels, and of 2,128,166 tons; so that in four years, viz., from 1866 to 1870, there was an increase of 4,991 vessels, equal to 3,816,454 tons.

With regard to foreign vessels there were cleared outwards in 1866, 24,575, equal to 5,086,656 tons, and in 1870, 24,751, equal to 5,835,028 tons, showing an increase of 176 vessels, and an increase of 748,372 tons.

Thus the total number of vessels, both British and foreign, cleared outwards in 1870, was 60,156, the total number of tons amounting to 18,526,818.

To navigate and man these vessels, it may be estimated that there are not less than half a million of men employed. As the number and speed of the vessels increase, so unfortunately do collisions become more frequent.

I have made out an estimate of the loss of property by collisions, and it is something like one hundred millions per annum. Whilst in 1869 the collisions amounted to 2,185, of which 157 vessels were totally destroyed, in 1871 they amounted to 2,561, of which 176 were entirely lost.

That steamers are rapidly supplanting sailing vessels is shown by the Board of Trade returns. In 1870 the tonnage of steam vessels built in the United Kingdom was 225,665, and of sailing vessels 117,032; making a difference of 108,634 tons in favour of steam.

In a very able article in the "English Encyclopædia," on Collisions at Sea, written by the well-known Mr. Saxby, R.N.,¶ it says, referring to the question of lights, "and committees and others who have ap-"proached the question of Collisions at Sea, all seem to have "neglected to give due prominence to the want of attention to that "which is the *root of the evil*, namely, that when ships are approaching "in opposite or oblique directions, no collision would be likely to "take place, *if one Commander knew what the other was about to do* "*with his helm,—positive safety hinges on this.*" Again, the same author says, "without the aid therefore of some further legisla-"tion, can we hope to prevent collisions. It may, however, be re-"marked, that if two persons are meeting carelessly on a pavement "collision is only avoided by one of the two knowing in proper time "what the other is about to do. The same remark applies to shipping; "a ready means of knowing in time the intended motions of an opponent "seems indispensable to safety."

The present system of lights has proved inadequate for the prevention of collisions.

Our invention, if adopted, would render collisions next to impossible; as it would supply the one thing needed, as mentioned by Mr. Saxby, viz., *enable one Commander to know what the other was about to do with his helm.*

It is true that the 13th article, of the "sailing rules," attempts to pro-

vide for the emergency of two ships meeting, but it often happens that other vessels are so much in the way, and in such positions that their regulation lights do not show, and for other reasons it is frequently impossible to obey this rule; it is thus left entirely to the judgment of the person in charge of the ship, which way he will put his helm, and should each vessel be steaming at the rate of 12 knots per hour, they would be actually rushing at each other at the rate of 24 knots an hour; there is thus no time to deliberate. A may imagine that B will put his helm to port, whilst B with equal justice may suppose that A will put his helm to starboard, the consequence is, that although each may have used his best judgment, for want of knowing with certainty, which way the other will steer, a collision ensues with probably great loss of life and property.

With the *side-lights* now in use, it is impossible at night to know when a vessel is approaching end-on, or nearly end-on, whether she sees you, and intends to alter her course, and, if she does, whether she will pass on the port or starboard side, hence arises, immediate danger to both vessels. It is often a source of anxiety to those in charge of a sailing vessel sailing by the wind "close hauled" "which side a steamer will pass, when she is coming on to the sailing vessel in a position abaft the beam where the regulation lights do not show to the steamer.

The adoption of our signals will not in any way interfere with the sailing rules or lights at present in use; it might almost be said they would not be additional lights, but simply, so to speak, a reflection of the existing ones, with the great additional advantage, that they would infallibly show, not only which way a ship is steering, but which way she is going to steer; in fact, reveal the mind of the person in charge of the ship.

There are other purposes to which these signals may be applied with great advantage, as for instance,—in piloting vessels into tidal harbours. The harbour-master could indicate the course a vessel coming into the harbour should steer, and at the same time, the vessel would show by the movement of her lights, whether she understood the directions, and is following them.

Again, in taking up a berth in a crowded roadstead or river, the "helm light" would show what sheer a vessel at anchor had; for example, a vessel's helm is lashed to port, the red light shows at once that is the position of the helm, and the cable will be leading on the port-bow; and if she is riding with starboard-helm, the light will be green, and the cable will be had from the starboard-bow, so that a ship coming in to anchor will know on which side to drop hers, and thus avoid taking up what is called a "foul berth."

I do not attempt to introduce a system that has not been fully tested. The "helm-signals" have already been exhibited and worked at sea in the presence of a Committee of Lloyds, and Lloyds' Salvage Association, and many other gentlemen, all of whom have expressed their entire approbation of them, and consider they should come into general use. I have also exhibited these signals at Liverpool with similar results, and particularly before the Mercantile Marine

Service Association. With your permission I will read two or three testimonials which I have received with many others. (See Appendix.) I may state that I have also had the honour of exhibiting our signals before Earl Granville, off Walmer Castle, from the "Palmerston" tug of Dover: she was sent out expressly in a gale of wind, in order that his Lordship should see the working of the lights at sea.

The apparatus (see Plate)* is so adjusted that it may be hoisted and lowered for the purpose of lighting or trimming the lamp, without the least trouble, thus avoiding the necessity for a man going aloft. It can be treated as the common steam-ship-light now in use, and is self-regulating, any cabin-boy can rig it, and being perforated at the back, the Officer of the watch can see which way the man at the wheel is steering, whether he is doing his duty, and obeying orders. He can also see whether the light is well trimmed and burning. If the man at the wheel should happen to fall asleep or to put the helm the wrong way, the officer of the watch can see it by looking up at the mast-head. At present it is impossible to know what the man is doing with the wheel except by standing at the wheel; you do not know whether he is giving one or two turns, but by looking at the indicator, which is very sensitive, it is impossible to mistake.

The whole apparatus is very inexpensive, and the mechanism so simple that it cannot get out of order.

This lanthorn, as you will perceive, is made in the form of an ordinary masthead lanthorn, with a circular burner at the back, which is surrounded by circular glass shades—one green shade, one blank, or metal shade, and one red shade: these shades are caused to move up and down (around the burner) by the movements communicated from the ship's helm. These shades also act as a chimney to the flame, and thereby consume the smoke and greatly increases the power of light.

The following are the advantages I claim for these signals:—Whilst they do not in any way alter the existing lights carried by sailing and steam-vessels, nor necessitate in any manner the alteration of the present sailing orders or "rule of the road at sea," they furnish an inexpensive and certain mode by which the course vessels are steering, or about to steer, is at once made manifest, and must consequently very greatly diminish the chances of collisions. They furnish a better method than the present by which vessels may be piloted by signals into tidal harbours, and they will also prevent vessels coming into crowded rivers and roadsteads, taking up foul berths.

Mr. Gray, of the Board of Trade, has in his Aids to Memory, made use of rhymes which he has got the sanction of the Admiralty to have printed in different languages, to set forth the rule of the road at sea. If Mr. Gray is right in theory, I certainly must be right in practice. He says,—

> "Meeting steamers do not dread,
> Port your helm and show the red,
> Green to green, or red to red,
> Perfect safety, go ahead!"

* Models also may be seen at the Office, No. 6, East India Avenue, Leadenhall Street.

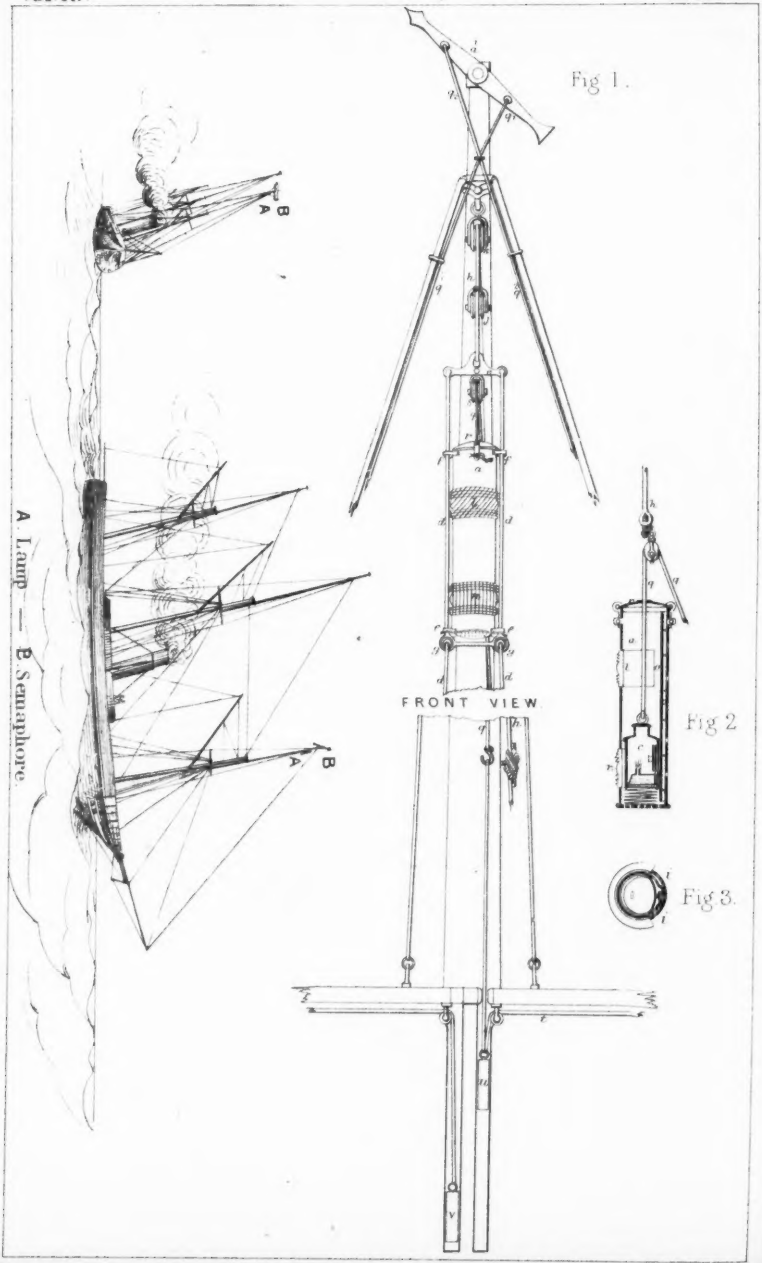


Fig 1.
FRONT VIEW
Fig 2
Fig 3.
A Lamp — B Semaphore

And in his third verse,—

"If to your starboard red appear,
It is your duty to keep clear;
To act as judgment says is proper,
To port, or starboard, back, or stop her."

I say,—

"If you don't know which way he'll steer,
The indicator makes it clear.
For if the helm to starboard goes,
The green masthead-light clearly shows.
But, if he with a port-helm steers,
The red light then aloft appears."

I will now show you the appearance of a steamer with the regulation lights (exhibiting a diagram), and here is a steamer in the distance with a starboard-helm light. With our helm-light it would be clearly seen which way he intends to steer. He starboards his helm, and you see by the light that he is bearing away to go astern of your steamer. If he ported his helm you would know that he intended to cross your bows. But with the regulation light the great question is, "Which side will he pass?" You wait for him and he waits for you; hence one-half of the collisions. But as soon as you see his "helm-light," (I do not care whether there is a look-out or not) you know what he is going to do. The man on the look-out may say, "There's a ship on the starboard bow; with starboard helm." The reverse, if so, with "port helm." By our arrangement if the officer should give the order to port the helm, and looks up at the mast-head, he can see whether the steersman has done it. If the man puts the helm wrong, the officer is able to detect it in an instant. It would also prove to the approaching ship that you intend to obey the rule of the road at sea and port your helm, and, of course, he would port also. It would also prove in the Admiralty Court the position of the rudder when the collision took place. This is the appearance of a tug (showing a diagram), which is compelled by law to carry two mast-head lights. Where those two mast-head lights are carried by the tugs, I should carry ours. Our light is equally clear on a stay or a backstay, or on any other part where it is considered suitable. Here is a diagram of a ship in the Downs riding in a crowded roadstead. I am running into the Downs, and I want to get a clear berth to anchor. With our helm light above the anchor light, a ship seeking a berth would say, for instance, "There is a ship at anchor with port helm, and the cable is on the port bow, I shall have a clear berth if I get on her starboard side." The two anchors will be at the extreme on the turn of the tide. Since I have been stationed at Deal, I have seen many vessels collide through anchoring in what is called a foul berth; they cannot make out each other's position; the consequence is, they have to slip their anchors, or they collide and smash each other up.

I will now explain the semaphore. The semaphore is simply a yard (which need not cost more than a shilling or two), made of wood and slung as you see it; the two lines are simply brought to the wheel ropes of the tiller. If the ship steers with the wheel on the bridge,

we have less gear. I propose to have a flexible wire rope, as wet or cold will not affect it. The semaphore would be of great use to steamships in the British Navy. I was cruising last summer, and saw a squadron, with the ships steaming one vessel after the other. It was difficult to know when a steamer was coming on behind at full speed, on which side she intended to pass. With this indicator there will be no doubt at all. We see the ship is porting her helm, and we know that she intends to come up on the right side. Reverse the semaphore, and it indicates that the ship is going to starboard her helm and to pass on the port side. Where the conformation of a river forms a bend, the hull of a vessel is often not seen at all; so the mast-head is the thing to look at; you see by the indicator that she has got starboard helm, and you know that she intends to go close round the point. The same with regard to lights at night. The present lights are deceptive. One vessel going down the river, and another vessel coming up, where the river forms a bend, the one shows the port light, and the other the starboard light; the consequence is that they cannot comply with the rule, without going right round each other's bows. With our light that difficulty is avoided. The light is slung in the ordinary way. It can be applied to the topmast stay or to the forestay clear of all square sails; and it can be lowered down. There is only one line to lower it down, and one line to trice it up.

I should tell you in conclusion that Lord Granville, who saw our plan tried, described it as "talking with the rudder;" and Mr. Gladstone, to whom I also had the honour of showing it, said that it was "the mute language of the rudder." He was much pleased with the illustration, which I had the honour of showing him, of our system. The great object I have in view is to save the lives of my fellow-creatures at sea.

APPENDIX.

From Sir Luke Smithett, late Manager, Royal Mail Packets, Dover.

I beg to state that I have, with several nautical and scientific gentlemen, carefully investigated Mr. Read's "HELM INDICATOR," as well as observed it when fitted on board a steam vessel for trial, and I am of opinion if generally known and applied to vessels at sea, many of the dangerous collisions which so frequently occur might be avoided.

The invention being simple, inexpensive, and easily applied, I can have no hesitation in recommending it to the shipping interest.

From J. A. W. Harper, Esq., the Secretary of Lloyds' Salvage Association.

Mr. Read has made an invention, which, after much consideration here, and *many experiments*, seems to those who have *conducted* and been *present* at the *experiments*, and have examined minutely the invention, very *complete*, and of *serious importance*.

The distinguishing points in this invention, are, that preserving the white light of a steamer unaltered, it presents two red lights when the ship has port helm, and

two green lights when she has starboard helm, and that the changes in the lights are mechanically effected by a communication between the lights and the wheel itself, so that whenever the wheel is put to starboard, the green lights present themselves, and on the contrary, directly the wheel is put to port, the red lights show themselves.

And it will be seen that even changes in the direction of the ship, to port or to starboard, will be indicated by the shifting of the lights, because the lights vary mechanically with every movement of the wheel.

Considering how many collisions there are in the course of twelve months, I am sure that anything which gives a real chance for diminishing that number is something that deserves attentive consideration.

From the President of the Mercantile Marine Service Association, Liverpool.

On behalf of the Mercantile Marine Service Association, and as its President, I have much pleasure in conveying to you the unanimous approval of the Council, of your "HELM INDICATOR," for the prevention of collisions at sea.

After a careful inspection of your model, and also after, what is more important, *an actual experimental test* of the invention on board a steamer engaged for the purpose, during the day time, and after dark as well, the favourable impression your explanations have made upon the Board was fully confirmed.

It is their decided opinion that the invention is a most simple, and at the same time a most faithful and admirable contrivance for preventing collisions, more especially in the case of steamers.

I trust that this expression of approval by thoroughly practical men may be the means of furthering the adoption of the invention to the general benefit of the sea-going portion of this and other communities, and of the public at large in the probable saving of life and property.

From Mr. J. B. Millen, Cinque Port Pilot.

Your invention for the better protection of life and property at sea, is both ingenious in its design and very simple in its working, which, if adopted, especially amongst steam ships, would prove one of the best means ever introduced for the prevention of those fearful collisions we so frequently have now.

Steam ships, by adopting your invention, would confer a great boon on those navigating in sailing ships.

It is often a source of anxiety to those in charge of the latter, when a steam ship is approaching, to know the intent of those in command of those ships, especially in narrow waters, whereas your design at once reveals, I may say, the mind.

I have had many years' experience in navigating between Dungeness and Gravesend, therefore feel some confidence in giving you my opinion; I have often thought that some such invention as yours was much needed.

From thirty-one Deal Pilots.

We, the undersigned Trinity Cinque Port Pilots, having examined your "HELM INDICATOR," are unanimous in our opinion that it is the most efficient and practicable invention, in conjunction with the present system of lights ever brought before the public for the prevention of collisions at sea, as it is at once trifling in cost, simple in its working, and not easily liable to get out of order, and that it can be placed at the "fore stay," or any other convenient place when there is not sufficient room between the fore yard and the masthead light. We are sure that your invention must meet with the hearty approval of all practical men as *the one thing long needed*, for by the very movement of the *helm* you at once communicate your intentions to any approaching ship, which fact must materially reduce the risk of collisions.

We sincerely wish your invention the success it in our opinion so richly merits, and that we shall shortly see it added to the present system of lights.

From Rear Admiral Sir W. R. Mends, K.C.B., to Clarke Aspinall, Esq.

Mr. Read has suggested a plan for notifying to ships the position of the helm by day or night. The plan is, in my opinion, simple in design though clever in conception, and is certainly deserving of the best consideration; whether adopted for the high sea by Board of Trade or not, it would assuredly be of service in narrow waters.

Mr. BUTCHART, Trinity pilot: I should like to ask one question with reference to the semaphore. Would it have a green ball on the starboard side, and a red ball on the port tide?—(Mr. READ: Just so.)—It is used at night?

Mr. READ: No, the semaphore is not used at night. In the river you are crowded with barges, and I propose this (showing a cheap kind of semaphore) as a semaphore for bargemen. If they could not get a rod of iron, they could get a broomstick, and sling it in the middle, and connect it with the tiller in order to show which way they are steering. (Really a cabbage at one end, and a bunch of carrots at the other, would answer the purpose, and at the end of the voyage they might be eaten.) Many collisions take place in the day-time, and it is quite as necessary you should know what a man is going to do in the day-time with his rudder as in the night. With such an apparatus as this there is no excuse for him.

The CHAIRMAN: Will you show the new lamps, which I see on the table, in action? Which of the two sets do you propose to adopt?

Mr. READ: This one has been lately finished, and is not quite perfect. I will exhibit the difference of the two. This one, I should tell you, is made out of a common ship's lens; it was made by myself. I converted the side lenses, and put them into this cylinder. I show three colours by the motion of the rudder; white with the helm amidships, green to starboard, and red to port. It is a question to be decided hereafter, whether a vessel shall show a white light representing danger with the helm amidships. With white for the helm amidships, I do not interfere with the rule which Government have sanctioned, that a tug shall carry a white light for a second light. But as soon as ever the helm is shifted to starboard, it changes the colour to green; and when it is shifted to port you see the red light. This is simply a common mast-head light, but it shows with this lens the different colours. The regulation lights would not be interfered with in any way. If the Board of Trade should decide upon adopting our lights to register the movements of the rudder, then, I say, "here are your regulation lights, with the white light for steamers."

The CHAIRMAN: In the new lamp I see you have no light at all for helm amidships?

Mr. READ: No. There is already a bright light carried by steamers at the mast-head, so that with this "helm-indicator" you do not want another white light.

The CHAIRMAN: Is it not possible to make that take the place of the ordinary white mast-head light?

Mr. READ: We could do so by putting the white light in the centre. At present it is a blank; but it could be made to show white, as well as red and green by putting another burner in the centre. But that is a question of detail to be decided on hereafter. Some persons object to showing a white light with the helm amidships, so I would rather have it blank. The white light with the helm amidships shows that the vessel is steering a straight course, and is coming dead on you.

Mr. BUTCHART: Where do you propose to fix this light on sailing vessels? I can quite understand the principle on board a steamer, but with all sails set?

Mr. READ: I propose to put it on the topmast-stay, or on a stanchion that may come up under the foot of the foretopsail. But I can place it anywhere; I can place it on the topmast stay, or I can lower it down wherever you like. This is another apparatus made of copper, made by another lamp-maker. It is a very powerful lamp on a dark night, but it is a very expensive one.

A VISITOR: At what distance can that light be distinguished?

Mr. READ: The red can be seen from four to five miles off; the green would be seen about three or three and a quarter miles. It is not so powerful; you cannot see the green as well as the red.

The CHAIRMAN: In all cases it is about the same as with the ordinary side lights? It is a question of power of lights.

A VISITOR: What would be the cost of the mast-head light?

Mr. READ: With the other gear, it would be something like from £4 to £5.

The CHAIRMAN: But the expense of burning would be no greater than that of the present mast-head light?

Mr. READ: No.

Mr. HENWOOD: What would be the expense of the apparatus you propose?

Mr. READ: That would depend upon the vessel. If the ship was steered from the bridge, the drift would be shorter, and, consequently, there would be less expense. I should say, that the whole apparatus could not possibly cost more than £10 for the biggest vessel afloat. Wire rope is cheap, and can easily be put in tubes, and sunk in the deck, and covered over in the water ways. The friction is no more than that of the ordinary gear with blocks and tackles, on board ship.

A VISITOR: Then, when this lamp with the bright light for "helm amidships," is shown on board a sailing-vessel, how do you distinguish her from a steamer? The steamer at present shows a bright light?

Mr. READ: The question is, whether the steamer shall have a white light, with helm amidships, or whether the sailing-vessel shall be blank.

The VISITOR: But if I understand you correctly, yours is an addition to the mast-head light of the steamer. (Mr. READ: It is.) Then the mast-head light would always be there?

Mr. READ: It would always be there. I do not interfere with the regulation lights in any way whatever. Mine is a useful adjunct to the navigator in order to reveal to a ship under weigh the mind of the man who is steering an approaching ship. A steamer steaming steadily on would show two bright lights; but that is a question to be decided hereafter. I propose to show to the approaching ship the motion of the rudder by the aid of the lights and semaphore. I consider that, if this helm-light is used as a position light, with white showing right ahead, green starboard, red port, it would do away with side lights altogether.

A VISITOR: Could it be used for lighthouse purposes?

Mr. READ: Yes, or for dock-heads and light-ships on dangerous shoals. The light-keeper would say, "There is a vessel running along, I am sure she will be on the Goodwin." He sends up a rocket, and begins to show one of these indicators. The man in the vessel says, "There's the light-ship, he is drawing my attention: he is giving me a signal to starboard my helm. He knows I am running into danger, he can see it."

Mr. BUTCHART: The difficulty in that case would be this. Supposing there were two or three vessels running in the same direction, how would any one of them know that the light ship was signalling to him especially?

Mr. READ: I can only explain it in this way. The "Gull" light-ship the other night fired a gun and sent up two rockets, pointed in the direction in which the ship was on the Goodwin. The rocket is always sent in the direction of the ship. We can see it from the shore, five miles off, and can tell where a ship is on the Goodwin because a rocket is sent in that direction. The same thing could be done in this case, a rocket could be sent towards the ship for whom the signal was intended, and it could be seen as plainly as a light.

Mr. BUTCHART: I have a good deal of feeling in favour of the present regulation lights, as neces-ary for all the purposes that ordinary navigation requires, especially for rivers, and for any part in fact. You said that the officer in charge would know whether the man at the wheel was doing right. Now, on board steamers you have the man on the bridge, and the officer of the watch is always beside him; so he knows, without taking notice of the light, whether it is green or red. He has got the man under his eye, and he knows whether he is porting or starboarding his helm.

Mr. READ: Of course, if you are always watching the man at the wheel. But your attention cannot be directed to two things: you cannot be looking out ahead, and seeing what the man is doing at the same time.

Mr. BUTCHART: But it is most important in a dangerous navigation, to have your eye upon the wheel.

Mr. READ: They have more often to look out for danger astern, where there is no light to be seen at all, than they have ahead; because if one steamer is going five knots, and another is coming up at the rate of twelve knots, they have to look out astern to see which way that vessel is going to pass. The indicator would show whether she was going to port or starboard.

Mr. BUTCHART: I am a pilot, therefore, I presume, I know something of the matter. It is a subject in which I have for a long time taken a deep interest, and in which some years ago I had something to do in bringing about the present regulation lights. Before the establishment of these lights on sailing vessels, I saw the value of them: and my difficulty at that time was to know on what part of the ship to carry them. Experience has proved that to carry them either aft or forward is of little or no moment. The great thing is that the light shall be seen right ahead, and only in that direction, and two points abaft the beam. When two vessels are meeting each other, the law provides that both vessels shall port their helms and show their red lights. If both vessels are end on they see each other's lights distinctly. If you lose sight of the green and get full sight of the red, you know that the other vessel is porting her helm. That rule is very simple, and is generally easily acted upon. But with all this, collisions will no doubt occur, as they have occurred; as long as we have so much traffic at sea, long dark nights, foggy weather, gales of wind, and all the contingencies and changes of sea, there will be collisions, and all that can be said or done will not do away with them entirely. However, whatever will lessen the amount or probability of collisions, whatever means are adopted or aimed at to lessen collisions, is deserving of support and sympathy, and ought to be encouraged. But in the river Thames, for instance, there are difficulties not easily to be provided for. I am in the habit of taking vessels down from the docks to the Downs. The present rule is that vessels going down shall keep the right hand, and vessels coming up shall keep the other hand, that is, both vessels shall act on the port helm. But this is a rule that cannot be applied in the river in all cases; no rule can be rigidly applied. It seems rather paradoxical to say that if you acted upon a port helm in some parts of the river, and in certain states of the tide, you would be on the wrong side entirely. Above Gravesend, especially, these hard and fast rules will not do. If I go down in the day time or in the night time, and show my regulation lights, I think that is all that is required. I have great faith in the present system of lights, as to their sufficiency for nearly all the purposes of navigation. But suppose I am using the "helm-indicator," there may be two or three vessels ahead—which vessel is to know that I am telegraphing to her that I am going to port my helm? I may intend to port my helm to the vessel on my port bow; I may not be thinking about the other man at all, yet he may suppose that I am signalling to him, because both see the indicator. Another thing, you know we have got very large steamers to take down and bring up, and they require a great deal of care and good management to pilot them safely. We frequently have to port the helm, not to alter their course, but to keep them in their course. But your indicator would show that your helm is a-port, showing that your intention is to go clear of another vessel; whereas, the object is to keep the vessel straight and preserve her course. (Mr. READ: Then, he must put his wheel over.) Of course, he has got his wheel over. But, then, in the day-time the side of the vessel is a very important thing to keep in sight. If I have got a view of the starboard side of a vessel, and the pilot, or Officer in charge sees my starboard side, there is no difficulty in avoiding a collision. But the difficulty and danger is, if you, by your indicator show that you are altering your helm, without any intention of going near the other vessel, and which you are not intending to go near. Then, again, in the river there are very sharp bends; passing from one reach into another, sometimes involves an alteration of course to the extent of ten points. This is a very serious matter. Then, with porting the helm, or starboarding the helm, as the case may be, the pilot, or person in charge, is obliged to preserve the course of the river as much as possible without regard to right or left of a sailing ship. Then, we have so much traffic in the river, especially with sailing barges. The number of these craft is enormous. Since the repeal of the navigation laws, the traffic on the river has increased amazingly. In our days the difficulty lies with them, not so much with sailing vessels. We have to be guided a great deal by circumstances; we cannot

abide by a hard and fast rule, and say, "I will keep on this side of the river and no "other." We cannot do that. I am obliged to port or starboard my helm without regard to any part of the river I may be in. Still, I said as before, there is a great deal of ingenuity about the scheme before us, and I should like to see it tested. I think it deserves the serious consideration of those who are interested in the question. It might answer in some parts, especially below Gravesend, or in the channel. Something was said about ships in tow of steamers. We know that according to the present regulation-lights a steamer towing a ship, is obliged to show two mast-head lights (8 or 10 feet apart); and as soon as we see the two mast-head lights, we know it is a steamer towing a ship. But if you are going to put a mast-head light on to sailing ships, according to the proposed plan, you will not be able to distinguish between a sailing vessel and a steamer. Then, something was said about guiding ships into harbours. I am not aware of any case where harbour-masters take any part in vessels entering a harbour of refuge. The pilot in charge is the person who is responsible; he is the best judge of the course he ought to steer. The harbour-master standing on the pier-head cannot tell so well. But I do not see how the harbour-master can in any way indicate to a vessel how he ought to put his helm. Again, about the anchor-light, there is something important to know about that. There are only two roadsteads in which the anchor-light as proposed would be available; that is the Downs and Yarmouth roads. In Portland, which is a large resort of shipping, it would be of no use at all, because ships always lie head to wind, for there is no run of tide at all. No doubt, when it is spring-tide in the Downs, and when the helm is an object, Mr. Read's suggestion is a very important one. But when it is neap-tide, and at other times, there is nothing for the helm to do; the ship lies head to wind. However, it is an important suggestion, and it is worth considering whether it could not be carried out. I have often, in trying to find an anchorage in the Downs, to observe which way a vessel is lying in regard to her anchor, and then to place my anchor so as to clear her. At night-time it would be very important for pilots, and others, in charge of vessels to know where there was a clear berth. About the changing of green, red, and bright lights, alternately, as shown by plan, showing that the helm is oscillating between one point and another, you must remember that lights at a little distance always blend. You would not be able to make anything of that at all, at least not distinctly. You would find at a certain distance the two lights would blend; you would not know whether it was red, green, or whatever colour it might be. I can only repeat that I am afraid the plan would not answer in the Thames. We have strong tides, and many things to contend with, which compel us to disregard these hard and fast rules, and to port or starboard as circumstances may dictate. However, it is a very ingenious plan, and the lecturer deserves very great credit. I hope it may succeed, and I think it may succeed in some places, and ought to have a fair trial.

A VISITOR: I am not a nautical man, but it appears to me that one or two of the last speaker's remarks cannot apply. He said, in the Thames he was obliged to put his helm hard-a-port in order to keep his course. (MR. BUTCHART: No: I did not say that.) In order to keep his course, or that he was obliged to work against the current by porting his helm or starboarding his helm; whereas the ship is not answering to it, but is simply keeping her course. I think it proves the use of the semaphore, because a vessel coming the other way would say, "It is nothing, he is doing all he can, he wont wash out against me, because I see his helm is ported," or the other way. With regard to the tidal harbour, it is perfectly true that the harbour-master cannot act. It very often happens that masters of vessels do not know the right tide at the harbour's mouth, so they often miss the entrance to the harbour; and a vessel often meets her death in trying to save her life. There is no reason why the harbour master should not be entrusted with a duty of that kind; or, in the case of a ship approaching the shore, why he should not guide it into the right path. With regard to the Thames, I know from experience that there are many currents in the Thames, but at the same time I should be disposed to contend that if I was working against the current by means of my helm, I am only showing to others what I wish them to know.

Another VISITOR: I am a young man and my experience is very slight, only about ten years on the river. For nearly a year I went a voyage up and down

the river Thames every week. It used to be my delight to be on the bridge with the Captains of steamers going down the river at one o'clock in the morning. I know their great difficulty was this, they were always saying, "Where is that man coming to? what is he doing? how are we to tell which way he is steering, or where he is going to?" Simply because there was a barge or another ship hiding the red light on the port, or the green light on the starboard bow. Whereas, if there had been a light above, which was not hidden, showing which way that steamer was coming, there would be no fear of a collision. There is one case in which I know a man was drowned solely because the Captain of our steamer did not know that the steamer was coming in the way it was, and the man was knocked overboard. Although young to express an opinion, still I feel sure that a light like this proposed by Mr. Read is of very great importance.

The CHAIRMAN: I have great pleasure in recognizing the extremely clever way in which Mr. Read has put the whole subject before us. I think the meeting will agree with me that considering,—I presume,—he does not claim to be a highly mechanical man, we could not have had a clearer or plainer illustration of what his views are. As to the question which has been discussed, as to whether this be or be not of utility in all cases, I can only say that knowledge is always useful; that those who misuse it when they have got it are very much to blame; and that when one comes forward to enable us to acquire knowledge—for which we have long been seeking—for use more in the open sea than in narrow channels, that man deserves great praise and recognition. I think the Institution will bear me out in saying that Mr. Read has given us a most important addition to our knowledge upon the subject. I have been struck with the simple and cheap way in which the plan is carried out. I have seen many plans of this kind, but I have seen none which approaches it in simplicity or in action; nor have I seen any plan which produces so many effects. I hope the Meeting will allow me to thank Mr. Read for his very able lecture.

Description of Plate.—*a*, the signalling cylinder shown suspended to a fore stay and within which cylinder the lamp *c* is caused to slide up and down in unison with the motion of the rudder in the manner to be hereafter described; *d*, *d*, guide lines fixed at top to a cross piece *e*, and at bottom to the deck or other convenient point of attachment. On these guide lines the cylinder is steadied and supported by the eyes *f*, *f*, which, in the ordinary position of the cylinder, rest on the thimbles *g*, *g*, or other suitable supports fixed to the guide lines. The cylinder is hoisted into position and the guide lines tightened by means of a line *h*, one end of which is attached to the cross piece *e*, and the other rove through the pulley blocks *j*, *k*, being then carried down to the foot of the mast where it is made fast. The block *j*, is provided with a ring which allows it to be raised or lowered on the stay *b* at pleasure. In openings in the front part of the cylinder are inserted the lenses *l* and *n*; the upper *l* being, say green; and the lower one *n* red; the said lenses are of the usual segmental form, in order to allow the rays of light emanating from the lamp to be visible over the requisite arc, or if preferred, they may be made circular so as to show a light all round.

The lamp *c*, Figs. 2 and 3, is constructed as an ordinary ship's lamp, by preference circular in plan and provided with reflectors suited to the arc of the lenses. A guide groove *o*, formed in it receives a tongue or fillet *p*, fixed in the cylinder prevents the lamp turning therein; the holes for the admission of air into the cylinder to support combustion in the lamp may be conveniently formed in this fillet (which is shown hollow), other holes being cut in the back of the cylinder to admit air into the hollow fillet; by these means draughts of air in the cylinder or lamp may be avoided. The lamp is attached to a lanyard *q*, which passes up through the cover *r* of the cylinder over the pulley block *s*, fastened to the cross piece *e*, and down the mast to near the deck, where it is attached to a line connected with some convenient and suitable moving part of the steering apparatus. This line connected with the steering apparatus may be a single line such as *t*, attached at one end to, say, the tiller, as shown, and being led by guide pullies, preferably beneath the deck, into a suitable position, has at its other end a balance weight *u*.

The motion of the steering apparatus in moving the rudder to one side, will thus impart to the line t, a movement in one direction raising the weight u, and when the rudder is moved to the opposite side, the weight will draw the line in the opposite direction. The lamp lanyard q being attached to the said line or to the weight as shown will receive a corresponding movement; a weight v, may also be applied to the other side of the tiller to counterbalance the weight u. It will now be understood that the lines q and t, being connected together in such manner that when the helm is amidships the lamp c in the cylinder is suspended in the centre of the cylinder and shows no light, any movement of the helm to the starboard or port side will depress or elevate the lamp so as to bring it opposite to the green or red lens, and thus indicate at a distance from the ship whether she is steering a starboard, or port course, and when desired the position of the lamp in the cylinder may be indicated to the officer of the watch through holes i, i, in the back of the cylinder provided with coloured glasses corresponding to the lenses. The line p should be attached to that part of the steering gear that will move the lamp from the centre of the cylinder to one of the coloured lenses, before the rudder shall have altered the course of the ship to any material extent (or if preferred, it may be so regulated as to show the light only at the last turn of the steering wheel either way).

The relative positions of the lamp and lenses are not altered by the further movement of the rudder in the same direction, by reason in the one case, of the lamp coming into contact with the cover r, and raising the said cylinder thereby, and in the other case by the lamp resting on the spring w, or on the bottom of the cylinder, the lamp lanyard q becoming slack; by these means the lamp can never be moved beyond the lenses.

The cover r of the cylinder may be removed to admit the lamp, after which it is closed and fastened by thumbscrews or staples and wedge, as shown.

Instead of the single line or rope t and balance weight u, an endless line and leading pullies carried round the ship beneath the deck in any convenient manner and position, or rods and cranked levers or other suitable mechanism, may be employed to impart motion to the lamp; and it will be seen, that if preferred, the lamp may be made to remain stationary, and motion only given to the cylinder by similar means to those described for moving the lamp. If it is desired not to exhibit a white light when the helm is amidships, the white lens may be omitted and the cylinder left solid between the red and green lenses.

Figure 1 also shows a semaphore or yard arm, arranged and operated so as to indicate in the day-time the movements of the rudder; a^1 is the semaphore arm centred on a pin and placed in some conspicuous position in the fore part of the ship, as on the mast; q^1, q^2, lanyards attached one to each side of the centre thereof; these lanyards are led down and connected to endless line or to the weighted lines before described, in such manner that the motion of the rudder shall elevate as shown, that arm of the semaphore which corresponds to the side of the ship towards which the helm is put over, and thus indicate the direction she is taking or is about to take.

Instead of applying the before described light-apparatus at the masthead one such may be applied to each side of the ship, and being connected with the steering gear will indicate in a more efficient manner than the present regulation lights the position a ship's helm may be in at any moment, by so arranging the lenses, that the colour visible shall be that which accords with the side to which the helm is put over, and when so applying, the apparatus we prefer to use a masthead or position light the front of which shows white, and the starboard and port sides green and red respectively, for the purpose of indicating the general direction a ship may be taking.

By employing a suitable notation and code corresponding to the colours and positions of the lenses in the cylinder, any required messages or signals may be transmitted by the above apparatus, whether on land or sea; and for this purpose several cylinders and lamps may be employed with the lenses arranged and combined in any suitable manner, the lamp being moved in the cylinder by hand or by mechanical means, as may be preferred.

HILL'S BOAT LOWERING AND SELF-DETACHING APPARATUS.

By Edward J. Hill.

The apparatus consists mainly of two patent slip hooks (*b b*) of peculiar form, securely fixed to the ordinary chain slings at each end of the boat. These hooks engage with the rings (*c c*) attached to the lower tackle blocks by short lengths of chain. So long as any strain is upon the rings they cannot be detached from the hooks, but on the strain ceasing, by the boat becoming water-borne, they fall away from the hooks, and cannot by any possibility hook on again unless held by hand in the right position for doing so.

In order to prevent one fall detaching without the other, in the event of the boat becoming prematurely water-borne at one end only, a strong rope (*f f*), called the life-line, connects the two rings by means of the double hook links, or shackles (*d d*).

The life-line (with the lanyard (*g*) slicked out) is hooked in as soon as the boat is hoisted to the davits, and is then set up or shortened by the lanyard so as to draw the rings into an oblique position, as shown in Figs. 1 and 2. The effect of this is that a portion of the strain borne by one ring is transmitted to the other, so that neither ring is ever sufficiently relieved of strain to become detached until *both* are relieved. When the boat is *entirely* water-borne, and both rings relieved of strain, the latter detach themselves, and the boat is free. The life-line (which, while in place, is useful for the men to hold on to) falls into the boat; the rings, chains, and shackles remain suspended to the blocks.

In lowering a boat it is thus only necessary to slack out the falls until the boat reaches the water, *when it will detach itself and float away*. If one end reach the water before the other, or be lifted by a wave, it does not disengage, and may either be recovered to the ship by hauling in the least fall, or the other fall may be slacked out until the boat is entirely supported by the water, with the result before stated.

The only circumstance under which the rings may sometimes fail to detach themselves on the boat floating, is when the boat is very slowly lowered while the ship has much way upon her *in perfectly smooth water*, in which case the boat is easily detached from the ship by one man canting the ring in the stern of the boat, by pulling the small cord fitted to the eye in the side of the ring. Immediately this is done the two rings are simultaneously released from the hooks, and the boat detached.

Another means by which the self-releasing shall be ensured under the above circumstance, is the adoption of a boat-rope as ordinarily fitted to take the towing strain of the falls. If the water is *not smooth* the motion of the waves will detach the boat, even if it is being towed (in the absence of a boat-rope) by the falls.

To raise a boat from the water the falls are lowered, and the rings

DISENGAGING GEAR PROPOSED BY Mr EDWARD J. HILL

Fig 1

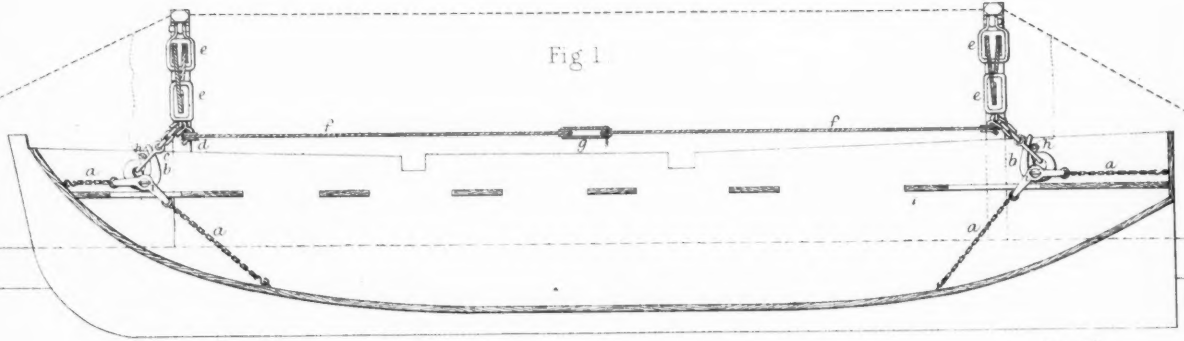


Fig 2

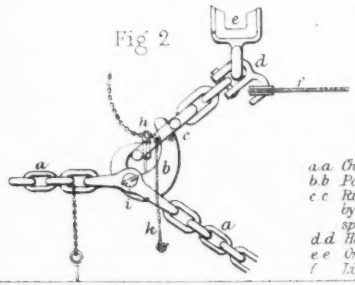


Fig 4

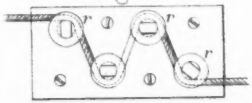


Fig 5

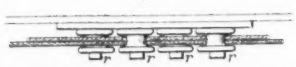
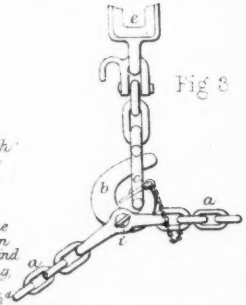


Fig 3



(Figs 4 and 5) Rollers fixed on a plate inside the bulwarks over which it is proposed to pass both falls to give greater controlling power over them in lowering and to ensure their going out together and the consequent descent of the boat on an even keel.

a.a. Chain Slings
b.b Patent slip hooks
c.c Rings attached to the lower tackle blocks by short lengths of Chain which disengage spontaneously when relieved of strain
d.d Hook shackles.
e.e Ordinary lower tackle blocks
f Life line preventing one end from detaching before the other
g Lanyard for setting up life line
h.h. Safety pins secured by small chains to the davits or guys. These pins are self drawn as the boat descends and remain behind. When hooking on, preparatory to hoisting other pins are used.
i.i. Rings to which ord.y steadying lines are attached
k. Lanyard for canting the ring c when required

passed over the hooks and attached in the manner shown in Fig. 3. The rings having been secured by safety pins, the boat is raised in the ordinary way, and the life-line is then drawn up as before explained.

When the boat is hauled up small, loose, safety pins (*h h*), attached by short chains to some part of the davits or guys, are substituted for the pins before referred to. The boat is then equally secure against being accidentally unhooked at the davits (as by a sea striking her, or in the process of turning inboard), while the pins *withdraw themselves* on the boat being lowered, thus preventing the possibility of mishap through the pins being unintentionally left in place.

It is claimed that the adoption of this invention will remove most of the risks incurred in lowering boats, either from swamping or from the detaching of one end before the other. It removes the necessity for leaving the detaching to the discretion of any of the men; an operation requiring great nicety and judgment in a heavy sea. It also tends to give confidence to the boat's crew, from the knowledge that the boat cannot be detached at either end until it has safely floated.

Mr. HENWOOD: Can you give some idea of the cost of your apparatus?

Mr. HILL: I cannot, as this is the first I have made, and I have not yet gone into it. I am not a sailor myself, but I wish those who are judges, to see my apparatus and ascertain its merits.

Mr. HENWOOD: I have fitted boats with both Clifford's and Kynaston's apparatus, and have objections to both of them. At present I do not see any objection to this plan, I think it is very good; and I think it is a matter which should be taken up by the Government, especially for the Royal Navy.

Lieutenant C. B. TEMPLER, late I.N.: There is one advantage that I see in Clifford's apparatus which I do not see in this, viz., that in lowering a boat in a sea-way to save life, the moment a sea strikes the boat, your tackle is disengaged, and she is left on the water, whereas by Clifford's apparatus the unreeving of the coil takes time, by which the man steering can steer clear of the ship.

Mr. HILL: I have always understood that Clifford's plan is not a slow one; he professes to be able to release the boat in fifteen seconds. (Lieutenant TEMPLER: The weight must be on the pennants to clear it.) It must depend upon the way in which the boat falls on the water. The boat lowered with my apparatus must in the first instance be in the proper direction of the ship, and if the boat then disengages itself the moment it touches the water, it would be in the best position in the world, because it would be parallel to the side of the ship.

Lieutenant TEMPLER: You cannot get clear of the lee of the ship; the lee of the ship would be pressing towards the boat, and that is the danger in a sea-way. Supposing it is a sailing ship, and a man is overboard (I presume the great object for which this apparatus for lowering boats has been devised is to save life), the ship must have a great deal of lee-way always, because you do not check her speed immediately, for very often the boat is lowered while the ship is going along; the ship would be going to leeward, and your boat would not be clear, she would be pressing under the counter, and would not get clear of the ship, whereas by Clifford's apparatus you drag the boat along to clear the pennants, and the coxswain puts the helm to starboard, and shoots her away from the ship, and the men can get their oars to work immediately. That is the only objection I see to the boat being lowered and disengaged so quickly.

Mr. HILL: It has always been my idea to get the boat clear of the ship as quickly as possible after it floats. It is the opinion of all sailors, that it is very important, in getting clear of the ship, not to have anything to unreeve after the boat is lowered.

The CHAIRMAN: I have the pleasure of saying on my own personal behalf that I have seen two inventions to-night (Mr. Read's Helm-signals and Mr. Hill's

boat-lowering apparatus), which, as far as one can see from the explanations given, I approve of very heartily. I see that there is a great danger which is common to almost all forms of boat-lowering, with which I am very well acquainted with, both to Clifford's and Kynaston's, and to every other that has been used, and that is, there is very great danger of the will in the boat not being the will on board the ship. I have seen men, with all the different forms of lowering, get into trouble, constantly; first, because the lowering apparatus was not in order, and, in the second place, because the men did not work together. The question of towing alongside is one depending on the ship's way. Neither pennants nor falls will ever succeed in towing a boat so as to give her lee-way, unless the ship has head-way herself. I see no reason why the tackles in Mr. Hill's boat cannot be kept on at the will of the persons in the boat. If it were required to keep them on, then they could be stopped from releasing themselves. But I quite agree with Mr. Hill that the right way to lower a boat, and the safest way, is that the instant she touches the water, she should clear herself from the tackles, and that there should be no hooks of any kind whatever, and nothing connected with the ship which may catch any part of the boat afterwards. There is a second, and, I am sorry to say, a much more fertile source of evil, which is, that the rolling of the vessel very often brings the boat against the ship's side; this, if not very closely attended to, may stove the boat. In some of the modern apparatus we have an arrangement of guides, by which the boat is kept from being injured in that way. I think the only addition I could suggest to such an apparatus as this would be from the fact that some of our iron-clads are given to most sudden and unpleasant movements, and smash up their boats by that movement. It would be a good thing to attach to the boats some addition which would prevent striking against the ship's side. There will never be, by either this or any other plan, absolute security against the destruction of a boat, should the bow by accident come down first, so that a sea can get into it. If the boat happens to come down too soon, and gets a thorough good sea upon it while the vessel still has way through the water, the boat would be lost. But I presume Mr. Hill does not expect to do away with all dangers and all difficulties, but simply to diminish all those that at present exist, and in these circumstances I think he has been extremely successful in this model, as far as it goes.

MR. C. E. PARKER-RHODES ON "A MILITARY BOOT OF HIS INVENTION."*

SEVERAL years ago my attention was directed to the way in which all classes were subjected to much suffering arising from badly shaped, or imperfectly fitted boots, and particularly by the considerable discomfort experienced by the soldiery of every country. Notwithstanding the perfection to which the weapons of warfare have been brought, the soldiers' feet have been entirely overlooked, or else the problem of a boot suitable to all emergencies has not been fully considered by those who might have solved it long since to the comfort of the soldier and to the economy of the national budget.

The soldier should be equipped in barracks as on the battle field, for immediate action, and if our Volunteers are ever to co-operate with the Army, they, like the regulars, should be always thoroughly prepared,

* Read at an Evening Meeting on March 18th, Admiral the Earl of Lauderdale, K.C.B., in the Chair.

and yet what has occurred in the case of the Volunteers, might at any moment happen to the Army, as will be seen by the following, taken from Official Report:—

At the review of the Volunteers, at Dover in 1869, by H.R.H. the Duke of Cambridge, Commanding-in-Chief, in consequence of a flood of rain which had fallen, and had forced the whole of the troops to seek shelter, when the storm ceased, and the review commenced, it was found that hundreds of men were unable to rejoin their corps through the impossibility of getting on their boots, these having been taken off and placed before the fire to dry in a saturated condition.

The Volunteers having to purchase their own boots, and being in nowise restricted to pattern and quality, it would be supposed that under every emergency on the occasion of a review, when every arrangement is made to convey them to the very ground on which they are to manœuvre, the possibility of their being disabled by the condition of their boots could never have arisen.

In May, 1869, in the columns of *The Times*, the boots supplied to the Army, were made the subject of comments by Officers, and it was then shown that the soldier's boot is a cause of continuous suffering to him, even when engaged in the lightest military duty.

The Franco-German War of 1870–71, brought to light the inability of the French soldier to march as events required, solely by reason of the condition of the boots supplied him by contract after the declaration of war, and when he was already on the march to meet the enemy.

The fraudulent fulfilment of those boot contracts by the manufacturers is being investigated by the present Government of France.

I have lately received from H.M. Commissioners of Patents the preliminary protection for a system of manufacturing military boots which overcomes all the defects and evils of the various systems now manufactured.

My system combines these advantages:—

1. Guarantee of solid materials used;

2 That to make a pair of boots by hand, would not occupy beyond an hour;

3. That the boots could at any moment be suited to the ease and comfort of the wearer;

4. That no damp, or wet, could penetrate to the soles of the feet;

5. That the soldier could in barracks, or on march, replace the worn sole and heel;

6. That the inside of the boot could always be kept clean, thus avoiding the cause of foot sore and other infirmities arising always from the bad construction of the present systems;

7. That the cost of this system of boot-making per single pair, would be considerably less than the actual lowest contract price;

8. That with the exception of the wearing sole and heel, this system of boot is of permanent durability.

It is the only system that meets the requirements for all out-door duties.

Mr. PARKER-RHODES: To prove the facility with which my system of military

boot can be manufactured, I have brought this rough model made entirely by myself. The materials of which it is made were easier for me to cut than leather.

A pair of boots for wear could be made by a practical hand in less than an hour. The cost would be considerably less than the actual price of any kind of boots as now manufactured; and their durability is unlimited, considering that the wearer can replace the worn sole and heel in a few minutes, wherever he may be, by having spare soles and surface heels supplied with each pair of boots; thus no inconvenience from uneven tread can arise.

The mode of fastening the boot enables the wearer to have a tight, or a loose fit according to comfort and ease for the foot.

When taken off, the entire length of the boot inside is laid open, and easily wiped out and dried, thereby ensuring a permanently clean boot.

The toe-cap or shield protects the whole front of the foot when walking over rough ground and against stubble, brambles, snags, or other obstructions, and against the entrance of wet or dust.

Admiral RYDER: The screw-heads would wear off?

Mr. PARKER-RHODES: They would only wear with the leather, and consequently would spread sufficiently to hold the sole firmly.

Admiral RYDER: To what extent is it used?

Mr. PARKER-RHODES: I have only just applied for Her Majesty's Letters Patent to bring the system under the notice of the War Office Authorities.

Captain BURGESS: Have you not shown your plan to the Emperor Napoleon?

Mr. PARKER-RHODES: I have the correspondence with me. I was invited to the Tuileries by the special desire of His Majesty, and explained the system, leaving a model of a boot made by me, and on the 16th March, 1869, the Duc de Bassano, H.M.'s Grand Chamberlain, wrote to me as follows: "His Majesty has directed me "to urge upon you to submit this model to his Excellency, the Minister for War, "when you have obtained your patent."

Captain BURGESS: Have you ever worn those boots?

Mr. PARKER-RHODES: Not yet. But on receiving provisional protection from H.M. Commissioners of Patents, I shall have some made for myself, confident of the superiority of the system over all present manufactures.

The Earl of LAUDERDALE: We are much obliged to you, Mr. Parker-Rhodes, for showing us the plan. I only hope the military authorities may approve of it.

Mr. PARKER-RHODES: It is a question of economy for the Treasury, as well as of permanent ease and comfort for the soldier. Having been closely connected with our merchant service in the discharge of my official duties in H.M. Consular Service, I consider the system would be a good one for our seamen.

The Earl of LAUDERDALE: For sailors the heel must not be so high.

Mr. PARKER-RHODES: The heel can be made suitable to the soldier and the seaman. I beg to thank your Lordship for this opportunity of exhibiting for the first time this simple invention.

The following extract from the final specification published by H.M. Commissioners of Patents, explanatory of the manufacture of his boot, and also a comparison of expenditure, are added at Mr. Parker-Rhodes' request:—

"This invention relates to the construction of a boot, shoe, or foot, "or foot and leg covering, which shall be capable of being at any "moment adjusted to the foot according to the requirements of the "comfort and ease of the wearer, and shall also prevent water or damp "penetrating to the soles of the feet, and shall likewise be capable of "being put on and taken off with great facility.

"To this end I construct the sole and heel in the following manner: "Between the inner and outer sole I insert an intermediate sole of "leather cloth, or such like waterproof material; I then secure a

"wooden, or leather heel thereto, and face the same with a wearing "surface of leather connecting the same to the wood (by screws by "preference), as that method enables the wearer to replace this wearing "surface as it gets worn away, I also prefer to screw on a clump "sole for the same reasons.

"The uppers I construct in the following manner:—I secure (by "screws by preference) the upper made in one or more pieces, between "the inner sole of leather cloth or such like waterproof material and "the outer sole. I then add a vamp shield reaching above the instep "of the foot or a toe cap, and screwed between the outer and clump "soles. I then secure the inside of the upper over the outside, as "also the vamp shield or toe-cap by means of eyes and buttons, "through and partly around which a single lace is passed and "fastened at the upper part."

COMPARISON OF EXPENDITURE.

Present Regulation Boot.	£.
100,000 men, two pairs each per year, at 10*s.*	100,000
Repairs per year, at 7*s.* per man	35,000
1. Expenditure for boots for one year	135,000
Or, for ten years	1,350,000
2. Expenditure for gaiters, three pairs to each man, in ten years, at 5*s.*	75,000
	£1,425,000

The Military Boot. *Invented by Mr. C. E. Parker-Rhodes.*	£.
100,000 men, one pair each for five years at 8*s.*, or ⅕th less	40,000
Spare soles and heels	10,000
	£50,000
3. Expenditure for ten years	£100,000
4. Saving in the War Office expenditure in ten years on every 100,000 men	£1,325,000

1. These repairs are now paid for by the soldier.
2. In some regiments each man receives one pair a year.
3. The soldier is provided for all kinds of weather.
4. This amount is far under the absolute saving to be made.

October 8th, 1872.

ON INFANTRY TACTICS.

Communicated by Lieutenant-Colonel W. J. Williams, R.A.

I. *Swarms of Skirmishers and Extended Supports.*

Some of our students of tactics now recommend to us swarms of skirmishers and ranks of opened-out files in support. No closed formation, it is said, can live under fire: we must attack and defend, especially we must attack, with swarms of skirmishers; and supports must be extended. These opinions seem to us to be zealous exaggerations. In their impatience of our old steady drill, and of our regulation of withdrawing skirmishers that we may have a steady line in front, some of our reformers are carried too far. They go with those German authors who have departed farthest from what is still the German regulation: we would rather hold with him who inspired the "retrospect of the retrospect." It was the German regulation which prevailed against the French army: the looser order of battle was tried only against the levies which France put into the field after her army was lost.

If we examine the theories of swarms of skirmishers and of opened-out supports, we find both theories wanting. Swarms of skirmishers is not a much safer formation for a given number of men under fire than formation in line; and opened-out supports must suffer as much as supports with closed files. It is difficult to fix the exact meaning of swarms of skirmishers; but we may fairly suppose that swarms of skirmishers would cover about the same front as would be covered by the same number of men in line. If the skirmishers were not equally distributed along their front, their loss, at that particular time, would be a little less than the loss of a line; but the tendency would be to an equal distribution along the front, and as the skirmishers should be more equally distributed they would suffer more loss. That the theory of opening out the files of supports to attain to greater safety is fallacious, becomes evident to us by the consideration that, in infantry fighting, supports are not aimed at. By the rain of fire passing over the skirmishers a company of 100 men in support would suffer equally, whether it were on a front of 40 paces or of 80, or of 120: each file would still be in the rain.

There is no doubt that the term "skirmisher-swarm," not swarms of skirmishers, gives a true picture of what the Germans saw when they looked at their first line in close battle. They saw that their first Line, with its reinforcements all in, had lost its organization of companies; and they saw that the men did not try to dress in ranks, but worked their way on here and there in groups. This disorder was properly named the "Skirmisher-swarm." We do not deny the power of the skirmisher-swarm. But we believe that swarms of skirmishers, sent out at first, would be wasted by fire until they were powerless. We allow that no regular formation can be maintained in the front line

of battle. But we deny the necessity and the advisableness of adopting a loose array for our supports.

The true principle of modern infantry tactics is to expose few men to the fire of the enemy, until, the enemy being close to us, or we being close to the enemy, our strength is wanted. The object is to bring our strength close to the enemy. The issue must be decided, now as heretofore, by the threatening advance of superior numbers ready with the bayonet.

II. *Necessary Change in our Tactics.*

The new conditions of musketry fire necessitate one chief change in our infantry tactics. We must cease to close skirmishers on their supports and to assemble skirmishers on their reserve.

Our field exercise aims at securing to us the effective delivery of our musketry fire: little or no care has been taken to provide against unnecessary loss in our ranks from the fire of the enemy. The regulation gives us skirmishers in front of our line; but the skirmishers are to run away to the rear, when the enemy comes close to them, or when they come close to the enemy. At what distance from the enemy are our skirmishers to run away and leave our line bare? The flight of our skirmishers, near the enemy, would ruin the steadiness of our line, if it did not immediately cause disaster. If our skirmishers were to come back to us at any safe distance from the enemy, our line would be exposed to the fire of skirmishers, and we should suffer more loss than we should inflict. In either case, we could deliver no fire during the flight of our skirmishers whilst the fire of the enemy would not cease. We must never withdraw our skirmishers. Our skirmishers must be the first to meet the enemy. To make our skirmishers strong enough to meet the enemy, we must reinforce them. The skirmishers, reinforced by all that may be left of the battalion, must fight in a skirmisher-swarm, that is to say, in line without regard to organization of companies and without regard to dressing. We must not be disturbed by the sight of our skirmishers running away round our flanks to the rear: our minds should be filled with the idea of advancing.

III. *Order of Battle of a Brigade.*

A brigade should consist of three or of six battalions, because the normal order of battle of a brigade is three Lines of equal strength. We will suppose that a brigade consists of three battalions. A battalion should consist of eight companies. A company should consist of sixty files.

The normal order of battle of a brigade is three Lines of one battalion each. In the open, there should be a distance of 300 yards between the first and second and between the second and third Lines. In the open, and under fire, our first battalion would be exposed to unnecessary loss if the whole of it were placed in front from the commencement: we should therefore divide our first battalion on three lines. In the open, then, and under fire, our brigade would stand on five lines. In front would be the two flank companies of the first battalion; at 150

yards in their rear would be Nos. 2 and 7 companies of the same battalion, as supports; and at 150 yards in rear of the supports, the remaining companies of the battalion, in reserve. At 300 yards in rear of the reserve of the first Line would be the second battalion in second Line. At 300 yards in rear of the second Line would be the third battalion in third Line. The two flank companies of the first battalion should be extended on a line of 400 paces, the proper front of a battalion and of a brigade: the companies in support should remain, each company, in closed line; the companies in reserve should be in line. The second and third battalions should be in lines. The brigade would thus stand on a front of 400 paces; and in the open, and under fire but distant from the enemy, the brigade would have a depth of 900 yards."

In this order of battle there is nothing new to our field exercise. We are accustomed to see a brigade formed with its three battalions on one Line or, at most, on two Lines; but these shallow formations are due to our practice of holding too great a front, and of dispensing, partly or wholly, with second and third Lines. Shallow formations would avail us, and would perhaps be necessary, against a numerous enemy inferior in *morale* and in arms; but only the deeper formation of battalion in rear of battalion could give us the chance of showing the value of our soldiers in a fair field against an enemy worthy of our best endeavours.

IV. *Defence.*

In the open, a brigade would stand on its defence in five lines ordered as above stated. The flank companies of the first battalion would stand on the line intended to be defended. All the formations would be in line, except the two companies in front, which would be extended on a line of 400 paces. In this order the brigade would remain under the cannon-fire preceding the attack of the enemy. This first cannon-fire would be aimed mostly at our guns which would be in line with and on the flanks of our two companies in front. Our infantry would suffer very little from this first fire; whilst they would all be near enough to come up in time to meet the enemy on the line selected for defence.

Our infantry should still be withheld, as long as possible, from the cannon-fire which the enemy would bring to bear upon us from his second artillery positions taken up nearer to our front. Only upon the appearance of the infantry of the enemy within 700 yards of our front, should our two companies commence to fire and our rearmost formations commence to close up. Although they would still for some time be exposed to the cannon fire which the enemy would direct upon us across the front of his attack, our second and third Lines must commence their advance as soon as our two companies have opened fire.

Upon the nearer approach of the enemy, it would be necessary to reinforce our two companies with the supports; to move up the supports nearer to the skirmishers, and the reserve nearer to the supports; to reinforce the skirmishers with two more companies; and, then, to throw the two remaining companies of the first battalion into the

skirmisher-swarm. These reinforcements should not be made too soon. Meanwhile, the second and third Lines should have continued their advance; and in their advance, the third Line should have much lessened its distance from the second Line. The third Line, on approaching the front, should form double company-columns. Upon the arrival of the second Line at a distance of 50 yards from the front, and the arrival of the third Line at 50 yards from the second Line, both Lines should advance. The first Line, in skirmisher-swarm, would then get up and lead the charge.

As we are here considering the fighting of a brigade only with reference to a certain order of battle, we do not propose to treat of attacks on a flank of the enemy striving to break in upon our front. We shall content ourselves with saying that some action against a flank of the attack of the enemy is almost necessary to the safety of the defence.

V. *Attack.*

In the open, a brigade should advance with its three battalions deployed in three Lines at distances of 300 yards apart. This would certainly be the best formation in which to advance under cannon fire.

On the arrival of the leading battalion within musketry range, or 700 yards, of the enemy, the two flank companies should run out, extending from their outer flanks, lie down at 300 yards to the front, and fire; Nos. 2 and 7 companies should run out, each company in line, and lie down at 150 yards to the front; and the remaining four companies should lie down in line. The second and third Lines should continue their advance. The skirmishers would then be at 400 yards' distance from the enemy; the supports and reserve at distances of 150 yards to the rear; and the second and third Lines would be closing up.

There should be as little delay as possible in the advance of the brigade. The object is only to get within charging distance of the enemy: to waste the enemy by fire is the proper duty of artillery, both before and during the attack. The skirmishers should gain ground by short runs, and always lie down to fire. The supports, advancing always at the double, and always lying down when not advancing, should gradually draw nearer to the skirmishers and reinforce them as they need reinforcement. The reserve, advancing always at the double, and always lying down when not advancing, should gradually draw nearer to the supports, and replace them, and then reinforce the skirmishers. The second Line should draw nearer to the first Line, and the third Line nearer to the second Line, both Lines lying down when not on the move. The third line should form double company-columns on its passage out of the zone of cannon-fire. All the formations in rear must conform with the movements of the skirmishers; and, at any time during the advance, every formation in rear should be near enough to support the formation next in front.

Before the arrival of our skirmishers within charging distance, or 50 yards of the enemy, the whole of the first Line should be in skirmisher-swarm. When the skirmisher-swarm is within charging

distance of the enemy, the advance of the second and third Lines, at distances of 50 yards, will cause the skirmisher-swarm to get up and lead the charge of the brigade.

What is urged against this method of attack is that the leading battalion, sent up to the front in successive detachments to spread along a line of 400 paces, would be a confused swarm, out of hand of the battalion-commander, out of hand of the captains, and not to be trusted to lead the charge. To this we reply that there is no other practicable method of advancing a brigade through the open, to bring it into contact with the enemy; and that men can be trained to act in a skirmisher-swarm as well as they could act in that formation which, within 50 yards of the enemy, should represent what, on parade, is a line. The impulse to charge, when at close quarters, cannot be communicated by word of command of battalion-commander or of captain, nor by sound of bugle, but only by the sight of a wavering enemy, or the resolute advance of a good support. The skirmisher-swarm, leavened by its Officers, would act, not by word of command, but of its own impulse. It is vain now to talk of any better line in front. No line could be marched up to the enemy; and if a perfect line could fall from the skies to find itself near the enemy, it would quickly assume the shape of a skirmisher-swarm. The disorganization of companies in the leading battalion must not be held to be an insuperable objection to the only practicable method of advancing a brigade to attack the enemy.

Again, it is objected that the skirmisher-swarm would not be able to manœuvre. To this we reply, that the skirmisher-swarm would have only to advance, and that it could reform at leisure when its work was done. Infantry have very little manœuvring to do in battle.

The objection that to drill for a loose method of fighting would be injurious to discipline seems almost unworthy of confutation. Much discipline is, no doubt, imparted by steady drill; and our soldiers may still be drilled to approach perfection; but both Officers and soldiers must be taught how to fight. A logical deduction from this objection is, that the discipline of our soldiers is partly dependent upon their stupidity.

VI. *Double Company-Columns.*

By double company-columns we mean quarter columns of four half-companies. A battalion in line would form four double company-columns on the right half-companies of right companies; or two central double company-columns on the right half-companies of Nos. 3 and 5 companies, the two companies on each flank remaining deployed; or double company-columns in the right or the left wing only, the other wing remaining deployed. The change of formation could be made on the move, at the halt, or with the right half-companies of right companies lying down. The columns would usually remain in line at deploying interval, under the direction of the battalion-commander; but a senior captain should command each double company-column much as in cavalry, a captain commands a squadron.

We advocate the formation of double company-columns in third Line

not under cannon-fire. This formation would undoubtedly be the best for the first and second Lines to rally upon should they be repulsed in attack or defence. We could usually form our third Line in double company-columns, when it had arrived within 300 yards of the enemy; for the cross cannon-fire of the enemy could seldom be brought to bear on us so close to him. Covered by two lines in front, the third Line would always suffer less from musketry-fire when in company-columns than when in line.

VII. *Conclusion.*

The order of battle of a brigade being as we have stated above, brigades would be placed side by side, not one in rear of another, in defence. Artillery would be placed in the front line in the intervals of divisions, so that guns would be separated from guns by intervals of two battalions, or about 800 paces. Cavalry, and the reserve of artillery and infantry, would be independent of the general order of battle.

In attack, brigades should advance one in rear of another, on a front of 400 paces, rather than side by side. A rear brigade would advance, at 300 yards distance from the rear of the brigade in front, in three lines with distances of 300 yards; and close its lines and lessen its distance from the brigade in front during the advance. An attack should always be prepared by artillery, and then supported by artillery well advanced on the flanks. Deep attacks on a narrow front are the most favourable to the action of the artillery of the attack; and by deep attacks only, can we reasonably hope to bring a superiority of force to bear upon the enemy. Two or more divisions, attacking together, would advance on a front of one division, or 800 paces; but 800 paces is the limit imposed upon the breadth of an attack, by the necessity of having artillery firing inwards across the flanks, in support, and the necessity of arising in superior force upon the enemy in his lines.

SHORNCLIFFE,
19th October, 1872.

LECTURE.

Friday, February 16th, 1872.

Colonel H. HUME, C.B., in the Chair.

THE CULTIVATION OF SCIENTIFIC KNOWLEDGE BY REGIMENTAL OFFICERS OF THE BRITISH ARMY.

By Major W. A. Ross, late R.A.

WHILE what may be called the *compulsory* study of the "applied sciences" is more exclusively required by Government from Officers of the Ordnance corps and those of the Medical department, the *voluntary* pursuit of any science is obviously more open to those of the Cavalry and the Line, and these latter have the equal benefit of a sound, gentlemanly education to start from as a basis, and the very great advantage of *leisure time* to enable them to pursue any selected science with success.

The groove of employment which the engineer or artilleryman has to follow in the Service, although not of the high scientific character which their preparatory examination would seem to have suggested, is nevertheless one of severe and incessant work; sufficiently so to debar him from the successful pursuit of any difficult science. In India—I affirm the fact unhesitatingly—these Officers are chiefly employed as cashiers or keepers of public accounts.

Now, cavalry Officers and those of the line have, as a body, a fair knowledge of general science; their regimental and office work is comparatively light, their pay is nearly equal to that of the artillery Officers, while their promotion—in the case of field rank, nearly trebling that pay—is immeasurably superior.*

It is thus that we find such a comparative majority of cavalry, line, and militia Officers coming before the public as inventors, travellers, sportsmen (who, if worth anything, are invariably naturalists), botanists, geologists, mechanists, and what not.

It is obviously to the advantage of Government to select for important appointments, from that body which affords the largest field for selection, and the Line Officers have, therefore, in this fact another great advantage and incentive to scientific study.

An extraordinary opinion or feeling has, until very lately, undoubtedly prevailed among military men, that scientific study of almost

* This was written, of course, before Mr. Cardwell's Bill passed.

any kind, is derogatory to their military character: this fatal folly appears to have been derived from the French army, who, even under Bonaparte in Egypt, held the very word *Savan* a term of contempt or ridicule. Bonaparte himself well knew the military value of scientific knowledge, and made perhaps his most lasting impression on the Turks in Egypt by means of the experiments of the chemist Berthollet. He himself, as is well known, was not only a devoted admirer of science, but a proficient in general scientific knowledge, and was wont, in this very Egyptian expedition, to puzzle the *Savans* he had taken with him—Monge, Berthollet, Cuvier, Lamarck, and others—with such questions as, "Are the planets inhabited? What is the age of the world? "Will the earth be destroyed by fire or water?" One of the greatest soldiers or sailors ever produced by England—Sir Walter Raleigh—was *also* the best chemist and most scientific man of his age; and Napoleon Bonaparte has originated a science—the combination of individual numbers and of masses upon given points—which may easily be applied, and, indeed, has been applied in illustration of the "atomic theory" of chemistry.

Now, of all the "applied sciences," the most generally useful, nay, the most indispensable to any or every profession, is undeniably chemistry, and chemistry also is popularly supposed to possess, of all scientific nuts, the shell hardest to crack. But surely, in its practical and most useful bearing, this is not the case? Viewed in its relation to mathematics, and especially to algebra, chemistry is no doubt an abstruse science, requiring the devotion of a lifetime to make a proficient, and it is possible in this sense, for a clever mathematician who shall take up the study of chemical theories, to write a profound treatise on that subject which might obtain the respect, and even admiration, of "the world of science," without himself performing a single practical experiment. On the other hand, it is also possible for an ordinarily educated and thoughtful man—an Officer of the Army for instance—almost entirely ignorant of all but the most simple and elementary chemical theories, as those of multiple and definite proportions, to procure by mere observant and pleasant experimentation, new combinations of substances which might prove of the utmost value and importance both to science and art.

It is, of course, easy to sneer and say, "Would you have every "Officer of the Army to be a chemist?" To this I would reply, "No, but I would have every Officer employ his leisure time in im- "proving his mental faculties by the study of some science which shall "call most of them into activity, and in this point of view there is "no study equal to that of chemistry."

It will be found, I think, that nearly every practical science depends, for the verification of its results, upon chemistry. Geology and Physics would be puerile if they could not refer to chemistry as the final and "exact" proof of their assertions. Even Astronomy is now laying bare her wonderful revelations of other worlds by means of the chemical analysis of light; and, finally, we must acknowledge that the science of war depends chiefly upon the due appreciation of "villianous saltpetre," or of compounds containing nitrogen.

It may again be asked sarcastically, if I would recommend regimental Officers to carry about with them violent acids and unpleasant precipitants, as a solution of sulphuretted hydrogen, test-tubes, beakers, filters, funnels, and all the fragile paraphernalia which the study of chemistry is supposed to entail? Again I answer, "By no means." I have here in my waistcoat-pocket a little instrument with which, simple as it seems, it may eventually be possible to perform an operation which the most complicated chemical apparatus has apparently failed to effect. I allude to the separation of the rare earth *Lanthanum* (derived from λανθάνω, I lie hid), from what has always been supposed to be, and is sold as "pure oxide of cerium," in which the former had in fact remained concealed, in spite of all the chemical processes to separate the two.

This instrument, as you see, consists of a couple of German-silver tubes, and a smaller one, terminating in a fine jet, with a needle-like hole in it: these tubes fit thus, one into the other, so that they will go into the waistcoat pocket. In my other waistcoat pocket I have two small stoppered bottles, one containing phosphoric, the other boric (formerly called boracic) acid. Having some platinum wire, a candle, and a lens, I am now accoutred as a travelling *geologist*, *mineralogist*, *agriculturist*, or *engineer*, sufficiently so to enable me to perform most of the qualitative analyses of the chemist, only otherwise possible with the acids, filters, test-tubes, &c., above referred to.*

This simple little tool—so different from the startlingly complicated machines one finds in the laboratory of the chemist or the *atelier* of the natural philosopher—pictures of which you will find *ad libitum* in Ganot's Physics—is, as I think, stupidly called a "blowpipe." But, however that may be, my business to-day is not with its name, but with its extraordinary utility, and with the unparalleled elegance and rapidity of its operations, which, in my opinion, fairly entitle it to be the humble but invaluable companion, not only of the wandering philosopher, of the Officer and engineer in the field, but even of the lady in her boudoir, for, avoiding the unpleasant and unwholesome smells which chemical operations entail, the results of this study, from which the student can draw scientific conclusions as accurate as marvellously rapid, are chiefly given in the shape of coloured beads or glasses, little inferior in brilliancy and hue to the gems of which ladies are so fond. I mention this fact especially, in acknowledgement of quite an unexpected pleasure afforded by the presence of so many ladies in this room. The magnificent translation of Dr. Schellen's work on Spectrum Analysis, just published, made by two young ladies, Jane and Caroline Lassell, shows how importantly the ladies can, if they like, assist in the dissemination of scientific knowledge.

One thing I must here mention—that this study, which I have ventured to call "Pyrology," is scarcely one for a public lecture-room. The very fact which constitutes one of the chief advantages of pyrological operations—the extreme portability of its apparatus—causes its results to be almost microscopic, and therefore unfit for exhibition be-

* It is said that Dr. Wollaston, who was a proficient in the use of the blowpipe, placed the whole of his chemical apparatus on a small tea-tray.

fore a number of auditors; and another disadvantage under which I labour to-day is, that having at present only a mouth "pyrogene"—as I propose to call the blowpipe—I cannot, of course, speak and use it at the same time; but a cheap, portable, and elegant blowing apparatus of vulcanised india-rubber is now made at Freiberg, in Saxony, which will enable the most delicate young lady or dandified Officer—for a great many clever men are also dandies—to use this invaluable little instrument without the facial disfigurement caused by using the mouth blowpipe.

To do the best I could, however, I have prepared beforehand a number of these "glasses," or "beads," of the before-mentioned phosphoric and boric acids—which, by the way, can be procured at any respectable chemist's shop, even in out-of-the-way stations, as those of India—by heating them thus, before the pyrogene, upon small pieces of platinum wire, twisted at one end into a loop or ring. You see that the acid, or "flux," as it is called, becomes quite red-hot, and thus, acted upon by the blast as well as by the conical blue flame proceeding from the front or jet of the pyrogene,—called by me a pyrocone,—revolves or spins round upon its centre with a rapidity which, avoiding as far as possible long words, has been found to be proportional to the fluidity of the matter of which it is composed. It must be quite evident, therefore, that any substance added to this red-hot bead in order to be dissolved in it by the combined action of the acid and the intense heat of the pyrogene, will be rapidly turned round—just as, only much quicker than, a leg of mutton is before a kitchen fire—so that every portion of the substance will be subjected to an equal degree of heat.

The bead I have now taken is one of *phosphoric acid*, which, as we all know, is present to an alarming extent in all our bones, and the doctors say in our brains also, especially in those of lunatics, but that I cannot believe!

You see at present that it is beautifully clear and colourless, and in its platinum wire setting looks something like a round diamond in silver. Now on applying the point of this blue pyrocone to it, you observe that is red-hot, and while in this state I just apply it thus to one of the small pieces of gold leaf lying on this slab of agate, and again bring the *other* side of the bead to the point of the blue pyrocone. The piece of gold, as you see, has disappeared, the platinum wire is apparently unaltered, and the bead or glass is as clear as ever, and even more brilliant; the gold, unable to stand the combined heat and powerful acid, has been utterly dissolved, and I have now here a brilliant colourless solution either of gold or of the oxide of gold. It will be very easy to prove which it is, although we shall now be treading on ground hallowed by the investigations of Faraday's mind, and even be compelled by the force of facts to hold an opinion different from that of the immortal philosopher on the subject,* for observe, I have now taken up several small pieces of gold leaf and dissolved them in the bead, to

* Faraday held that the ruby colour bestowed by gold upon glass and fluxes is due, not to the *oxide* of that metal, but to *metallic gold* in an infinitely small state of division: the above experiment proves that it is due to an *exact* amount of oxidation of the gold.

which I now add a little more phosphoric acid, and hold it *not quite so far* as I have been doing from the point of the blue pyrocone. I will now ask some one near me to observe this auriferous brilliant glass while it is getting cool. There is no change—but the glass is not nearly cool yet—but now, see! it flushes over with a most beautiful bluish rose colour, as pretty as that of the finest amethyst. Many of my fair hearers would give much to have a gem like this for their rings, but unfortunately this ruby bead will not last, as the bead will soon become sticky and unpleasant by absorbing moisture from the atmosphere. On the other hand, what would not the illiterate digger of Australia give to have a simple and rapid (as well as beautiful) test like this for the gold he may suspect to lurk in the crushed quartz?

Here is another "glass" of the same flux. It looks quite clear also, and even after making it red hot by holding it a long way from the point of the blue pyrocone, you see that it remains quite clear and brilliant. You will probably guess from this fact, that there is nothing dissolved in this bead, and if so, you will be very far from the truth. There is at least 5 per cent. of the oxide of *silver* dissolved in it, and now, mark the effect of my holding it just inside the tip of the blue pyrocone; the bead is a perfect image of a fine *pearl*, and this beautiful reaction is an excellent test for 5 per cent. of the oxide of silver.

I now take another glass, also clear, and in no way distinguishable from what the others were at first. It is, however, composed of a very different, though analogous substance—*boric acid*. It is the substance which apparently separates those rare earths of which I spoke, *cerium*, *lanthanum*, and *didymium*, when they are all combined in the so-called "pure" ceric oxide; I am not, however, going to trouble you with such long names, or such slippery substances, about which I know as little as any one else appears to know. Instead of this, I heat this clear glass as before, and having applied a mere trace—there must be no more—of our old friend phosphoric acid to it, heat the whole again. Watch it as it cools. You see that in about five or six seconds it clouds over, but a yellow light still shines from within, causing the bead to be an almost perfect imitation of the noble opal; could this be only kept in its present state, it would not disgrace the fingers of the ladies. This is a rapid test for phosphoric acid in minerals, which acid I have little doubt is the cause of the unique beauty of the opal, at present attributed to "organic matter."

Time will not allow me to show you a tenth part of what I should like to do, in illustration of this elegant—and, as I believe, important—mode of analysing inorganic substances, but I cannot refuse myself the pleasure of showing you what I really think was a valuable discovery made by myself in India, in 1869.

Here is another glass of phosphoric acid. I am going to dissolve in it some oxide of the metal *cobalt*, known, I presume, to most present as the substance which gives to glass and porcelain the beautiful blue colour, *bleu de roi*, which we have often seen; and indeed it is just in this fact that I consider I may fairly call the experiment I am about to make a "discovery," for in all "blowpipe" tables and chemical works

of the present day, you will find the chromatic reactions of cobalt given as blue, and blue only.

Now observe the difference. You will say "What difference? the glass is only blue;" but wait awhile, it is only half cool. You see as it cools to what a charming colour it changes: a deep purple violet, as we should call it, or, as the ladies would call it, "magenta." I now add to this bead a little common salt, and heat all together. You see the glass now *remains* blue when cool, and this is effected by the sodium of the salt, for just 17 per cent. of soda or potash will cause this beautiful red glass to remain blue on cooling, causing it to be a valuable measure of alkali in substances, or an *alkalimeter* which you can put into your waistcoat pocket.

I must now conclude, but before doing so, I would ask your attention for a few moments to these parcels of earth spread on the table before me, the meaning or use of which you will probably have been trying to conjecture. They represent various specimens of the substance which the Government of India has for the last 10 or 12 years been using as a *limestone* in the manufacture of the mortar with which their vast and palatial double storied barracks and other public edifices have been built.

Now by this "limestone" there hangs—as Shakespeare and Darwin tell us—a tale. It is found throughout almost the whole of the vast plains of India (and nowhere else, I believe), occurring from 6 to 10 feet below the surface of the ground, in what the geologists call concretionary tufaceous nodules, or something like that, but the illiterate natives have applied to it a much shorter name, "kunkur," by which it is now universally known.

Lord William Bentinck, when Governor-General of India, first applied this "kunkur" to a purpose for which it is admirably suited, that, namely, of "road making," in which it is hammered and crushed upon the public roads with water until it forms a paste, which is shortly baked by the powerful Indian sun into a kind of porcelain coating or "metalling," as it is technically called, and which is so hard as to form the finest roads in the world. It is said—but please don't repeat it—that his lordship was ever afterwards called "William the Kunkurer," but the author of this atrocious pun has, it is hoped, been secured and deposited in Hanwell.

Some one—I don't know who—without the perception of Lord William Bentinck, suggested the use of kunkur as a limestone for making mortar, for which the kinds generally found are quite unfitted, as they only contain 20 per cent. of lime, and even that is bound up in a peculiar way with silica, so as to make the whole utilisation of the lime by burning difficult, or even impossible. This kunkur has been treated by the Indian Government in the manufacture of the mortar of their "palaces of cards," as though it were a pure limestone, for they mix one-third of it with two-thirds of pounded brick (called "soorkhee"), or with common earth. I am sure that nobody present will deny that 20 is one-fifth of 100, so that the Indian mortar contains only one-third of one-fifth of lime in 100, that is one-fifteenth!

I now heat with the pyrogene a specimen of good limestone mortar,

taken from a private house at Mussoorie, in India. See how it glows. By putting, now, a drop of this cobalt solution upon it while still hot, you see that it turns immediately a pretty blue. Now let us try this "mortar," taken by myself from the wall of one of the palatial tumble-down barracks above referred to, in the same way. The cobalt solution does not change its appearance in the least, but it remains very much like a substance too common in the streets of London—mud. The barrack from which this specimen of "mortar" was taken, cost more than £10,000; it has a fearfully heavy roof of stone, and on the occasion of a high wind, after rain, a company of the 88th, as I am informed, rushed out of it, declaring they would stay no longer in it, as it was dangerous. Now this is by no means a solitary instance, but, on the contrary, *all*, or nearly all, the later barracks, post offices, and public buildings between Calcutta and Peshawur have either fallen down, are unsafe, or are just kept habitable by constant repair at an enormous expense.

In one instance, a steam-engine from England was put up in one of these buildings at Allahabad, which, at the first stroke of the piston, came, as was to be expected, to the ground, killing several people, and wounding more. This was too much even for the good nature of the late Lord Mayo. He ordered the "mortar" to be sent to Calcutta to be analysed, and the analysts found in it the economical proportion of just 5 per cent. of *lime!*

It has been published in the newspapers, and never contradicted in India, that the total amount of public money thus wasted on these buildings during the last ten years is no less than £45,000,000!!

The Indian Government attributed the fact (which is not denied) of the failure of these buildings, to their Officers in the department of Public Works having been cheated as to the lime by the native contractors, and removed several of the former from their appointments, but the cause evidently lies—as above explained—in the use of this *kunkur* as a pure limestone, which use was *ordered* by the Indian Government itself.

If I have not trespassed too long on your patience, I will just add a few words to show how such humble knowledge as that I have described may become important to a Government which is not above making use of it. I see on one of the back benches, a gallant Officer who, as I remember, applied to the Chief Engineer in Bengal—a Colonel of the Engineers whose name I forget—for me some twelve years ago to join the Department of Public Works in India; the reply received was in the negative; but I had at that time, brought to India from Freiberg, one of Plattner's complete blowpipe apparatus, with assay balance, &c., and I cannot but believe that had the Government then accepted my services, I might at least have been able to have convinced them of the real nature of the *kunkur* employed, and thus have had the satisfaction of adding my mite towards a knowledge that would have prevented the series of colossal failures in public buildings above adverted to, of which the barracks at Saugor—which cost a trifle of £166,000—are the latest instances *brought to light;**

* These barracks are, according to the *Times* of December 3, 1872, ordered to be

but there is no doubt that *all* the later barracks and public buildings in Bengal and the north-west of India, are in the same unsatisfactory state.

Thus you see that a little of the scientific knowledge I have here attempted to indicate, might have saved the Government of India some *forty millions sterling!*

THE AUTUMN MANŒUVRES OF THE PRUSSIAN GUARD-CORPS IN SEPTEMBER, 1872.

Communicated by Lieut. HENRY J. T. HILDYARD, Adjutant 71st H.L.I.

NEARLY two years have already elapsed since the grand review of the German Army at Longchamps previous to its homeward march, and since that time there had been no considerable assembly of German troops for the purpose of exercising until the manœuvres of the Guard Corps in the vicinity of Berlin during the month of September of this year. There is every reason therefore to look upon these manœuvres, carried out without hurry and with sufficient preparation, as specimens of the results drawn by the Germans after a careful consideration of their experiences during the late war. We cannot indeed regard any new movements practised, as their definite conclusions, for no new instructions have been issued since the war, but we may take great interest in watching what are still with them only tentative measures, for under these circumstances we are the more likely to see their defects, and to hear them freely discussed by themselves as well as by others.

As has been explained very frequently of late, there is a considerable difference between the German peace-manœuvres and our own, inasmuch as the former adopt a system of billets, which necessitates pre-arrangement, and limits the movements to certain bounds. But apart from this, it is not always considered equally instructive for one manœuvre to last for several days on a very extended scale, as in that case the instruction derived is in a certain degree restricted to a limited number of Officers in high command, whose plans but too often become common property and are subject to free discussion long before they are put into execution. A great portion of the time also in this case is necessarily occupied by strategical marches which, although of

abandoned, and the constructor, Captain Faber, R.E., to be dismissed from the Department! Poor man; *he* was not to blame.—W. A. R.

NOTE.—The lecturer has received the honour, since this lecture was delivered, of having his paper on "Pyrology, or Fire Analysis," read before the Royal Society, in Vol. xx, No. 137 of the proceedings of which Society it will be found, and may be referred to by those desirous of more detailed information on this subject, which, however, cannot be found in any of the published works on the "Blowpipe," as the fluxes and their reactions above mentioned, were introduced by the writer in 1869, and have been used by him only, as yet. A work on the subject will shortly be published by Messrs. Spon, of Charing Cross. Messrs. Horne and Thornthwaite, of Newgate Street, will supply the apparatus required in this method of analysis to Officers at a moderate cost.

undoubted value, can be practised equally well by brigades and lesser bodies of troops. The usual German plan which is to manœuvre from day to day with fresh dispositions and fresh aims, although the original general idea is often adhered to, affords a series of varied and definite lessons to those in high command, and gives at the same time a greater amount of practice to the subordinate Officers and men.

It has been said, that in peace-manœuvres, so soon as the two opponents come into close contact, the game is at an end; but I do not consider that this is strictly the case, except perhaps from a strategical point of view. Undoubtedly the student of pure strategy will feel that his study is more or less at an end, but tactics take its place, and though many of the elements which would decide perhaps in real war are wanting, sufficient remain, the proper employment of which, require most careful and continual study. Were movements to be checked so soon as the two conflicting forces were deployed for action, not only would an opportunity be lost for the working out of tactical problems which vary so much according to the ground and many other considerations, and which nevertheless require fixed general outlines, but no practice would be afforded in the very difficult matters of pursuit and retreat.

Hoping that my preface will be sufficiently accounted for by a desire to call attention more especially to the subject of tactics, which is the branch I propose to treat of, I will now proceed to describe as shortly as possible the two greater manœuvres of the Guard-Corps in the vicinity of Berlin on the 9th and 10th of September, the former of which consisted of a manœuvre of the entire corps against an imaginary enemy, and the latter of one in which it was divided into two parts, acting one against the other.

Manœuvre of Corps against Imaginary Enemy, September 9th, 1872.—*General Idea.*

The Guard-Corps has been brought up to the relief of the invested fortress of Spandau. On its approach, the enemy having raised the siege and evacuated the left bank of the Havel, takes up a position in the vicinity of the fortress on the right bank with considerable forces, in order to cover the withdrawal of his siege material.

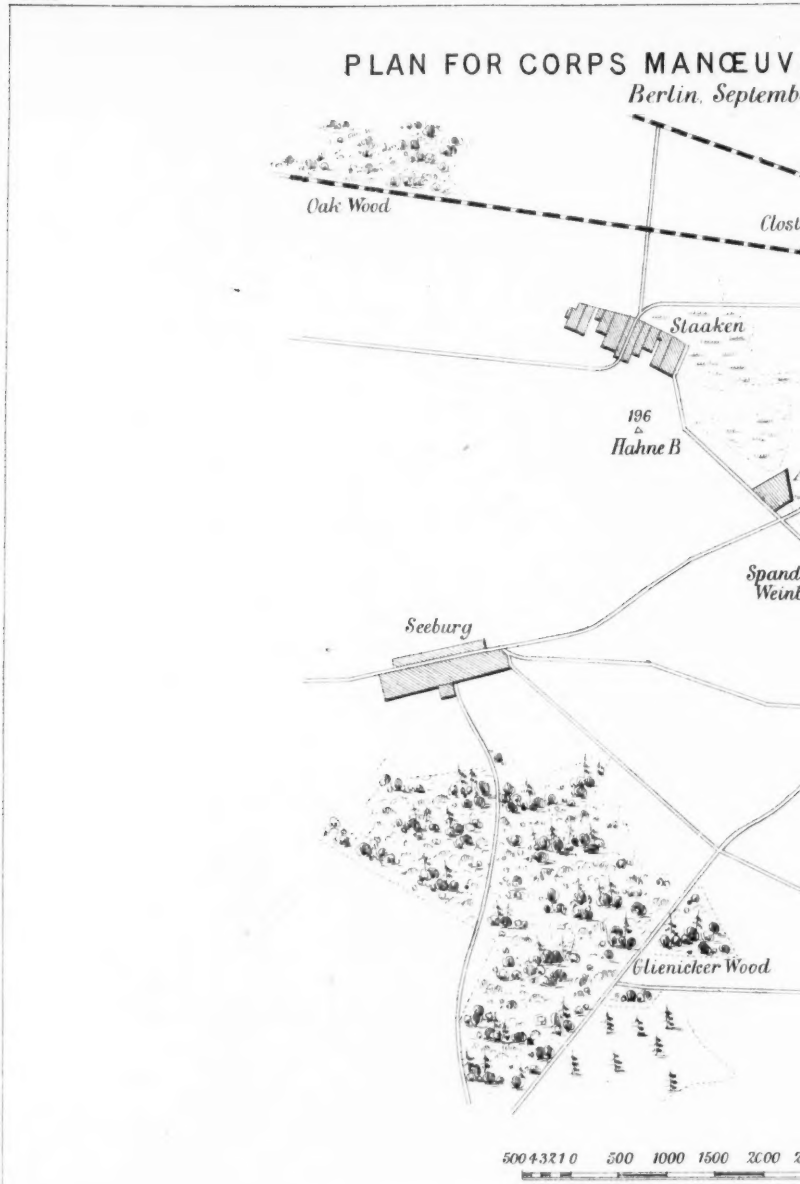
Special Idea.

The commander of the Guard-Corps having advanced with the main body of his forces, close up to Spandau on the night of the 8th September, and pushed his advanced guard through the fortress upon the right bank of the Havel, decides to attack the enemy's position on the heights west of Staaken and Amalienhof on the 9th, turning his right flank, and to force him to retreat before he can secure his siege material.

Partition of Troops.

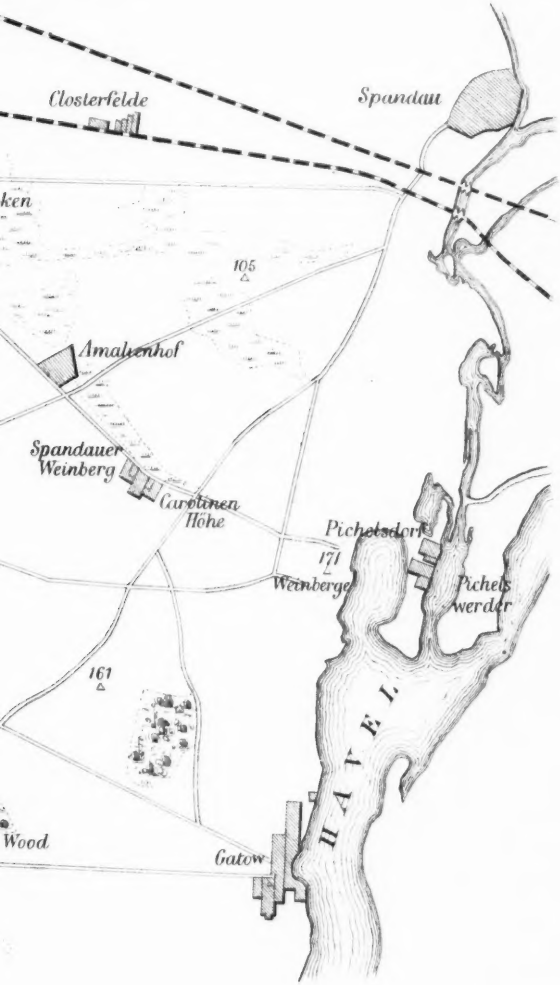
1st Infantry Division, Lieut.-General v. Pape.

1st Infantry Brigade { 1st and 3rd Foot Guards. / Jäger battalion.


PLAN FOR CORPS MANŒUV
Berlin, Septemb
Oak Wood
Clost
Staaken
196
Hahne B
Spand
Weint
Seeburg
Glienicker Wood
500 400 300 200 100 0 500 1000 1500 2000

NŒUVRE OF PRUSSIAN GUARD

September 9th 1872.



0 2000 2500 3000 3500 4000 4500 5000 Paces

2nd Infantry Brigade: 2nd and 4th Foot Guards; Hussar regiment.

1st Foot Division of the Field Artillery Regiment (4 batteries of 4 guns).

2nd Infantry Division, Lieut.-General v. Budritzki.

3rd Infantry Brigade	Emperor Alexander's Grenadier Regiment. 1st and 3rd Queen Elizabeth's Grenadier Regiments. Rifle battalion.
4th Infantry Brigade	Emperor Francis Joseph's Grenadier Regiment. 2nd and 4th Queen Elizabeth's Grenadier Regiments. 1st Pioneer Company.

2nd Uhlan Regiment.

2nd Foot Division of the Field Artillery Regiment (4 batteries of 4 guns).

Corps Artillery: Colonel v. Helden-Sarnowski.

3rd Foot Division of the Field Artillery Regiment (4 batteries of 4 guns).

Horse Artillery Division of the Field Artillery Regiment (2 batteries of 4 guns).

Left flank detachment, Major-General Baron v. d'Goltz.

Fusilier regiment and combined infantry regiment.

Three companies Pioneer battalion, with light field bridge train.

1st Brandenburg Uhlan regiment.

Instruction battery from School of Gunnery (4 guns).

Cavalry Division—

1st Cavalry Brigade	Gardes-du-Corps regiment. Cuirassier regiment.
2nd ,,	1st and 3rd Uhlans.
3rd ,,	1st and 2nd Dragoons.

1st Horse Artillery battery (4 guns).

Disposition.

Head-quarters, Spandau,
8th Sept. 1872, 5 *o'clock p.m.*

The Guard Corps will attack the enemy's position on the heights of Staaken and Amalienhof to-morrow, turning his right flank.

The first infantry division and the corps artillery, the latter following the foremost regiment of the main body, will debouch from the Potsdam gate at 8.30 o'clock. The division will form up for the attack of the Amalienhof heights and the Spandauer-Berge, supported by the corps artillery, which will march near its right.

The second infantry division will begin to debouch from the Aranienburg gate at 8.15 o'clock, and will push forward its advanced guard against Closterfelde and Neu-Staaken in order to possess itself of these places and engage the enemy on the heights. The main body

will advance 1500 to 2000 paces in rear of it, and form temporarily the reserve of the corps for my disposition.

The left flank detachment will protect the throwing of a bridge from Pichelswerder to Pichelsdorf, which must be finished by 8 o'clock, and at 8.30 o'clock it will be directed by the latter place towards the Carolinen heights, keeping somewhat in advance of the left of the first infantry division, reconnoitring towards Gatow and Gr. Glienicke.

The cavalry division will cross the pontoon bridge immediately after the flank detachment, and will form up in rendezvous formation, fronting towards Seeburg, and covered by the Carolinen Heights. Reports will find me with the main body of the first infantry division.

(Signed) AUGUST,
Prince of Wurtemburg.

The greater portion of the Guard-Corps had bivouacked on the afternoon of the 8th. The main body of the first division was at Charlottenburg and Ruhleben, and a small portion was cantoned in Spandau. The main body of the second division bivouacked south of Haselharst, the advanced guards of both divisions west of Spandau, the left flank detachment in the Grunewald at Pichelsberg, from which place a bridge of boats had been formed to Pickelswerder, a small island in the Havel, occupied by a battalion in the Fusilier Regiment.

Early on the 9th September, the advanced guards of both divisions were ready to commence the forward movement, the first close before the Potsdam Gate, with posts of observation on the other side of the suburb, that of the second about 1,000 paces west of the Spandau works on the railway leading to Hamburg and Lehrte.

The left flank detachment had in the early morning constructed a pontoon bridge and a bridge of casks from Pickelswerder to the right bank of the Havel, the former of which was utilised for the passage of the infantry, the latter for the other arms. At the given times, the heads of the respective columns were set in motion.

The advanced-guard of the second division on the right formed up from column of march as a first attack, which was subdivided into three lines in the following manner:—In the first line was a subdivision of each of the two leading companies of battalions extended in skirmishing order, followed in second line by the remainders of these companies in section-columns about 40 paces apart and 100 paces from the extended line. The third line was composed of the remaining companies in half battalion formation, about 200 paces more retired. The advance here was carried out without opposition, ground being gained for the main body to form up, the villages of Closterfelde and Neu-Staaken being occupied, and the enemy's attention called to this flank, which was the immediate object in view, so as to allow of the turning movement on the enemy's right being developed without serious opposition.

At the same time the advanced guard of the first division, covered by the fire of its battery, which was escorted by a portion of the Hussar Regiment, formed up whilst advancing over the open ground in its front, and gained sufficient ground along the road leading to the Carolinen Heights to allow the main body time and space to deploy.

The Corps artillery went rapidly forward in the meantime to an advanced point (105) between the two divisions, where it formed up and opened a continuous fire upon the heights occupied by the enemy, about 2,000 paces to its front.

The left flank detachment was at this time marching upon Seeburg; the cavalry had not completed the passage of the stream.

As soon as the first division had completed forming up, which it did in two lines of battalion-columns at full distance, the brigades side by side about 100 paces in rear of the guns, with the regiments in rear of each other, and 50 paces apart, it prepared for advance in the following manner. The foremost line sent two companies per battalion to the front, which formed three lines, the first two in extended order, with barely half-pace intervals between men, the third in sections in close-order. The remaining two companies of the battalions of the original first line were in half-battalion formation, forming a fourth line, whilst the regiments in the original second line formed a fifth line, composed of battalion-columns at full interval. This formation was completed in rear of the guns, the first line being aligned with them, and as soon as sufficient effect was considered to have been produced by the artillery-fire, the cavalry passed to the front to clear the ground. The general advance of the division then commenced by echelon from the left, which was composed of the second brigade. This advanced by moving off in the first place its first lines, followed by the second at a distance of 80 paces, the third following at an interval of from 100 to 150 paces, followed by the fourth at about 300 paces; the fifth line followed considerably in rear. This movement was supported by a battery on the left belonging to the flank-detachment, which was ascending the heights north of Gatow, and advancing towards Seeburg. Advancing rapidly by running forward, and lying down at intervals, this brigade carried the Carolinen heights, whilst the first brigade, forming the right, advanced against the Spandauer-Weinberge, which were quickly occupied, assisted by the fire of the second brigade from its new position. The divisional artillery now moved forward on to the heights and opened fire against the Hahnenberg, whilst the Hussar regiment followed the retreating enemy, and the first brigade possessed itself of Amalienhof, close to which the artillery took up a still more advanced position, and continued to fire rapidly in the same direction.

About the same time the left flank detachment, which had been advancing with slight opposition towards Seeburg, proceeded to its attack, which was done by an advance of the infantry very similar to that of the first division. Advancing to the close vicinity of the village, the whole lay down, the first line being reinforced by both the second and third, and a very rapid independent fire opened. An advance was then made by subdivisions, which fought their way through the village, the divisional cavalry coming to the front and pursuing for a short distance on the other side. The Corps artillery having been released from its first object by the occupation of Amalienhof, now advanced to a position between the latter place and Staaken, whilst the artillery of the second division formed up on its right. That of the first division was already posted on the heights, and the battery of the left flank detach-

ment and of the cavalry division was near Seeburg. From these points the fire of the whole of the artillery was now concentrated upon the position Hahnenberg-Staaken, whilst the infantry prepared for the final advance, with the exception of the main body of the second division, which moved off to its right in the direction of the Oak Forest.

The final attack was now made by the first division and the advanced guard of the second. This was carried out in the original loose order by rapid and short advances, the extended lines breaking up into groups on arriving at close quarters, and pushing steadily forward, with the exception of one regiment in column of companies on the centre. Whilst this was progressing, the left was advancing to the left of Seeburg. As soon as the enemy's retreat was decided, the cavalry, which had been kept back in a sheltered position behind Seeburg, advanced in columns of squadrons, the Cuirassier brigade on the right, the Uhlan brigade on the left, and formed up in two attacks, four regiments in first line and two in second. The former rode straight forward to the attack towards the chaussée, reining up only when close to it, whilst the latter turned to its left to meet the enemy's cavalry, supposed to have been pushed forward on his right flank, and which was already suffering from the fire of the flank-detachment battery.

At the same moment that the cavalry was re-formed, the general halt was sounded, which brought the manœuvre to a close, when the troops stood in the following positions:—

The advanced guards of both divisions in an alignment with the artillery advanced close up to the road leading from Staaken to Dallgow, whilst the main body of the second division had reached the Oak wood. The main body of the first division was drawn up on the Hahnenberg.

The simplicity of the plan and the evenness of the ground allowed every movement to be followed with comparative ease, though, owing to the large extent of the front, it was not possible to witness personally every detail.

The manœuvre of the 10th September consisted of one division acting against the other, the general idea being drawn from the results of the manœuvre of the previous day. The corps was divided into an east and a west division, the former of which represented the attacking force of the day before, or a portion of it at least, and the west division, the retreating enemy.

Special Idea for the West Division.

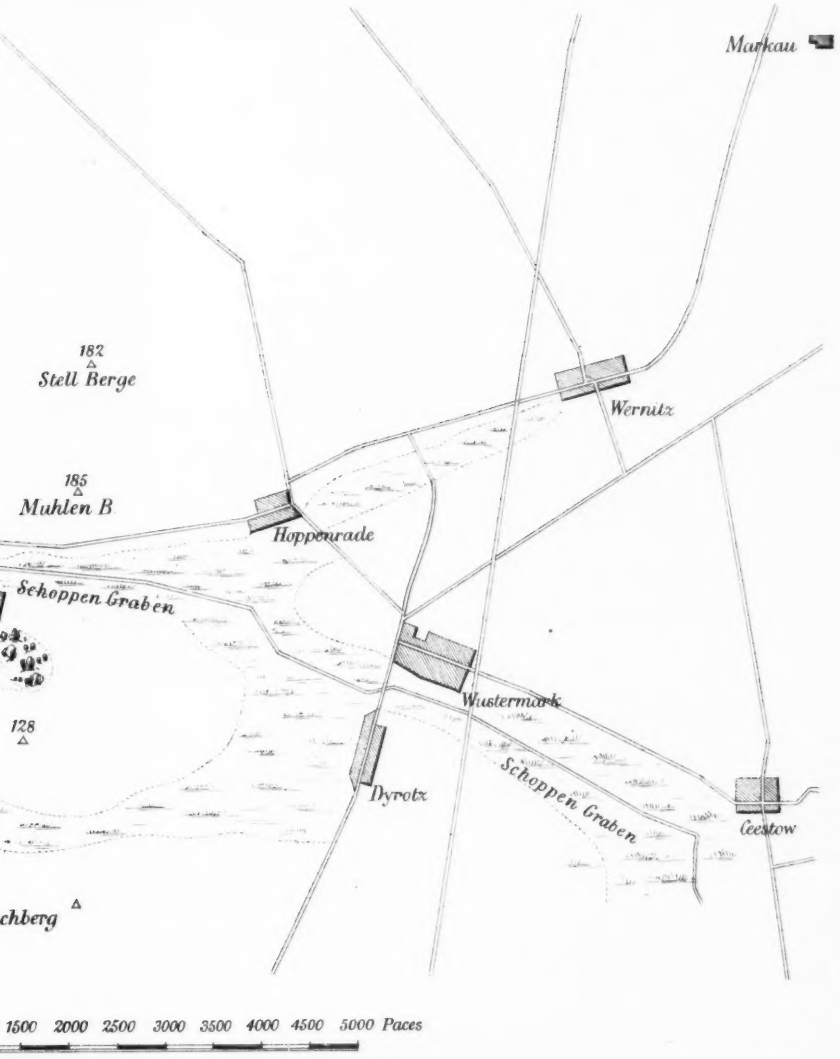
The west division having been forced to retire from its position on Hahnenberg, on the 9th September, by very superior forces, and been closely followed, continued its retreat over the Schöppengraben. Weak outposts still maintain themselves to the east of it, as the enemy has only advanced a short distance beyond the line Ferbitzer-Bruch and Rhins-hake.

The divisional commander is instructed to maintain the defiles over the Schöppengraben until noon, on the 10th September, and then to


PLAN FOR MANŒUVRE OF PRUSSIAN G
Berlin, Septe
188
Belvedere
to Etzin
171
Weinberge
Falkenrede
Stell
Buchow
Muhle
KL Paaren
Fichtenberg
Sekoppe
Carpzow
Wublitz See
128
Priort
Kartzow
Saltzkorn
Eichberg
6 0 0 4 3 2 1 0
500
1000
1500
200

AN GUARD_ DIVISION AGAINST DIVISION.

in, September 10th 1872



J Jobbins

retire in the direction of Brandenburg, leaving only posts of observation in front of the enemy.

Special Idea for the East Division.

The Guard Corps, after having beaten the enemy's investing corps on the forenoon of the 9th September, on the heights south-west of Spandau, received at noon the order to detach the second cavalry brigade and a portion of the first division, strengthened by the corps artillery, in the direction of Potsdam, whilst the second division and cavalry division, and a great portion of the corps artillery, is formed into an east division, for the purpose of following the enemy in his retreat upon Nauen.

In the evening the outposts stand in the ground close to the west of the Ferbitzer-Bruch and Rhins-hake, the main body east of the Schweinekuten-Graben. Weak posts of the enemy are still to the east of the Schöppengraben. The commander of the east division receives the order to attack the enemy (west division) again, and by pressing on his right flank, to endeavour to throw him into the Havelbruch.

The heads of the advancing columns are not to cross the line of outposts before 9 o'clock in the morning.

Disposition of the West Division for the Manœuvre of 10th September, 1872.

Staff-Quarters, Hoppenrade,
9th September, 1872.

The division has crossed the defiles of the Schöppengraben, at Dyrotz, and Buchow-Carpzow to-day, and bivouacked with the infantry between Wustermark, Wernitz, and Hoppenrade, the cavalry and artillery at Hoppenrade.

The advanced guard is posted as follows :—

2 battalions, 1 company Jägers, 1 squadron, 1 battery, at the Windmühle.

1 battalion, 1 company Jägers, 1 squadron, 1 battery, at Buchow-Carpzow.

1 company Jägers, 2 sub-divisions Hussars, in Ceestow and Bredow.

1 company Jägers, 1 sub-division Hussars, in Falkenrehde.

The remainder of the Hussars immediately to the west of Dyrotz.

The Pioneer detachment in Dyrotz.

The outposts somewhat in advance of this line.

The bridges over the Schöppengraben, at Falkenrehde, on the way from Buchow-Carpzow to Doeberitz, at Ceestow and Bredow, are so far destroyed as to only allow of the passage of patrols, and are prepared for complete destruction.

In this position the division will endeavour to defend the Schöppengraben until noon, and then retire upon Brandenburg by Nieselde and Tremmen.

The advanced guard will give early information regarding any movements of the enemy.

Partition of Troops.

Commander: Lieut.-General v. Pape.
Officer of the General Staff: Captain v. Nickisch-Rosenegk.
Aide-de-Camp: 1st Lieutenant Brunsig Edler v. Brun.
Advanced Guard: Colonel v. Papstein.
Fusilier Regiment: Major v. Feldmann.
Jäger Battalion: Major v. Arnim.
Hussar Regiment: Colonel v. Hymmen.
5th Light and 5th Heavy Foot Batteries: Captain Gizycki.
1 Pioneer detachment.
Main body—
1 Infantry Brigade: Major-General Count v. Kenitz.
3rd Foot Guards: Colonel v. Thile.
1st Foot Guards: Colonel v. Boehn.
2nd Infantry Brigade: Major-General v. Krosigk.
4th Foot Guards: Colonel v. Grolman.
2nd Foot Guards: Colonel v. Appell.
1st Foot Division of the Field-Artillery-Regiment, Major v. Heineccius.
2nd Cavalry Brigade: Major-General Prince Hohenlohe-Ingelfingen.
1st Uhlans: Colonel v. Eller-Eberstein.
3rd Uhlans: Colonel v. Schenck.
1st Horse Artillery battery.

(Signed) v. PAPE,
Lieut-General Commanding 1st Guard, Infantry Division.

Disposition of the East Division for the Manœuvre of the 10th September, 1872.

Staff Quarters, Doeberitz,
9th September, 1872, 6 *p.m.*

The defeated enemy has retired behind the Schöppengraben, towards Nanen; weak outposts stand to the east of the former.

The east division will attack the enemy again to-morrow, and pressing him from the direction of Brandenburg, will force him upon Nauen, or into the Havel morass. The first column will pass the line of outposts at 8.30 a.m., and close the defile Dyrotz-Wustermark, against a possible offensive. The second column will cross the advanced posts at 8.30 a.m., and march upon Carpzow by Priort, and will secure the Buchow-Carpzow defile. The infantry of the third column will be north of Ferbitz, at 8.30 a.m., the two cavalry brigades, the artillery, the pioneer detachment, with the bridge material, and the sick transport waggons, will be ready at 8.30 a.m., with the head of the column at the Schaafdamm bridge. The column will go by Satzkorn (the infantry by Kartzow, where a bridge will be thrown), and Klein-Paaren to Falkenrehde. The column will clear the Carpzow-Buchow defile for column No. 2, and hinder the enemy in his retreat upon Brandenburg.

I shall be with the second column.

Partition of Troops.

Column No. 1.: Major-General v. Knappe.
Emperor Alexander's Grenadier Regiment (No. 1): Colonel v. Zenner.
Rifle Battalion: Major v. Böltzig.
3rd squadron: 2nd Uhlan's, Colonel v. Rochow.
6th heavy battery.
Pioneer detachment with two intrenching tool waggons.
Column No. 2: Major-General v. Dannenberg.
Emperor Francis Joseph's Grenadier Regiment (No. 2): Colonel v. Wangenheim.
Queen's Grenadier Regiment (No. 4): Colonel v. Lucadou.
Queen Elizabeth's Grenadier Regiment (No. 3): Colonel v. Hüllessem.
2nd Squadron: 2nd Uhlans.
2nd Foot Division Field Artillery Regiment and 6th Light Battery: Major v. Krieger.
Pioneer detachment with 1 Trestle bridge waggon.
2 sick transport waggons.
Column No. 3: Lieutenant-General Count v. Brandenburg.
Combined Infantry Regiment: Colonel l'Estocq.
1st Cavalry Brigade: Colonel v. Krosigk.
Gardes du Corps Regiment: Colonel Count Hynar.
Cuirassier Regiment: Major v. Kleist.
3rd Uhlan Regiment: Major v. Möllendorff.
3rd Cavalry Brigade: Colonel v. Brandenstein.
1st Dragoons: Lieutenant-Colonel v. Brozowski.
2nd Dragoons: Major v. Lützow.
Horse Artillery Division of the Field Artillery Regiment (2 batteries): Major v. Graevenitz.
Instruction battery: Pioneer detachment, with 1 Trestle bridge waggon; sick transport waggon.

(Signed) v. BUDRITZKI,
Lieutenant-General Commanding 2nd Infantry Division.

The outposts of the west division were posted as follows in front of the Schöppengraben: at Ceestow and at Dyrotz one company of Jägers each, supported by two battalions of the Fusilier regiment behind the latter place. At Priort was a third Jäger company, and at Carpzow a battalion of the Fusilier regiment in support. Another company of Jägers was at Klein-Paaren, and a subdivision of Hussars was pushed forward to Satzkorn.

Owing to the nature of the ground, the advancing columns of the east division could not be seen, but by the positions of their guns upon opening fire and by the clouds of dust which arose wherever the troops were in movement, the general dispositions of its commander could be fairly divined, and the commander of the west division took his measures accordingly. Leaving only one regiment in Wustermark,

he concentrated the greater portion of his forces on the Mühlenberg behind Buchow, sending the Uhlan brigade with two battalions of infantry and a horse battery to Falkenrehde.

Column No. 2 was the first to come into contact with the outposts of the west division, which it did at Priort, driving them back upon the battalion in support, which was stationed in the wood on the left front of Carpzow, supported by a battery on its left. The fire of this was shortly afterwards answered by two batteries from the Eichberg, which supported the infantry's advance. The latter pressed close upon the retiring Jägers, but on cresting hill (128) it was received by a heavy fire from the wood, which caused it to pause and correct its formation. The Emperor Francis Joseph's regiment was in front, and the new formation was adopted to its fullest extent, for the three first lines were all extended, being supported by the remainder of the battalions in company-columns. The ground was remarkably favourable for this formation, as the approach was over an undulation sloping towards the enemy at only a couple of hundred paces distance, which enabled all the lines to fire during their advance, which was done without even pausing. From about 50 paces the ground rose again towards the wood, and on this, about 40 paces distant, the first line lay down, being successively reinforced by the second and third, and still more by the extension of sections here and there from the supporting companies, and a very rapid independent fire was opened. During this time a company was advanced by the left flank in file, so as to take the enemy in flank and rear. The enemy eventually fell back, after an enormous expenditure of ammunition, to Buchow, and the village of Carpzow was entirely evacuated, and occupied in force by column No. 2. The main body, however, accompanied by the artillery was directed by the heights north of the village against the Mühlenberg, between which and Buchow the enemy's artillery was posted. All attempts however to throw a bridge over the stream were unsuccessful. In the mean time a periodical fire was kept up along the whole line of the stream without any decisive effects, except that the passage could not be effected. A battery belonging to the advance guard of the west division kept up a steady fire from a very favourable position on the Fichtenburg until driven back by musketry fire. In this position the centre remained for upwards of an hour from before 10.30 to 11.30 o'clock, the east division attempting to effect a passage, but being frustrated on every occasion by the vigilance of the opponent on the other side of the stream.

In the meanwhile the cavalry of the first column having debouched from the wood in front of Dyrotz, was received by a heavy fire and forced to fall back precipitately behind some sheltering ground. Shortly afterwards the infantry debouched also, and advancing in extended order, succeeded in bringing the 6th heavy battery into position. It was, however, impossible to maintain it on account of a heavy musketry fire from a subdivision of Fusiliers, and the battery was forced to fall back. On the advance of the infantry, however, the subdivision retired, but in spite of every endeavour it was not able to dislodge the infantry of the east division, which had partially in-

trenched itself, shortly before 11 o'clock, though the latter and to fall back to take the place of the 2nd regiment, which had been drawn off to the centre, at the Wustermark, where it maintained the line of the Schöppengraben until the order was received at 12 o'clock to relinquish the position.

At about the time that the action came to a stand in the centre and left, the third column approached Klein-Paaren. The dragoon brigade after passing through Satzkorn, arrived at the passage over the Wublitz marsh west of Klein-Paaren, and obtained possession of it. As, however, the bridge was supposed to have been destroyed, half an hour was fixed by the umpire for its re-establishment. In the meantime reinforcements from the west division enabled its advanced posts to resume the offensive and regain possession of the passage. The village of Falkenrehde was now strongly occupied by the 3rd regiment of Foot Guards, whilst the horse-battery opened fire upon Klein-Paaren.

The infantry of the third column marching by Kartzow had found it impossible to establish a bridge there, on account of the marshy nature of the ground, and was therefore considerably delayed. On the arrival of its advanced guard however, the bridge was again regained, and two companies followed the retreating enemy. These were attacked by the united Uhlan brigade, which came upon them from three sides, and the umpire's decision was against them. The main body of the column now began to debouch, followed by the Dragoon brigade, but the whole had to retire on account of the success of the Lancers.

A second advance against Falkenrehde failed on account of the heavy musketry fire of the troops occupying it, and only after considerable preparation by the fire of three batteries massed north of Klein-Paaren was a third and final attack undertaken. The infantry of the west division now evacuated Falkenrehde and fell back upon Buchow, the horse artillery taking up a position at point 171, where it was supported by the Uhlan brigade, which was in rear sheltered by a slight dip in the ground. The cavalry of the east division now advanced to the west of Falkenrehde, and formed up in two lines ready to meet the Uhlan brigade. It was forced to retire however by the artillery fire, and was followed by the Uhlans, but without coming in contact.

In the meantime some detachments of the second column had succeeded in effecting the passage of the stream and had obtained a footing in the wooded ground at the foot of the Mühlenberg. In consequence of this, and also on account of the time fixed for the holding of the position having almost expired, the Commander of the west division relinquished his hold upon Buchow, and retreated towards Etzin. As it happened, this was done at exactly the right time, for had he maintained his position, his line of retreat would have been most seriously menaced by the advance of the enemy on his right flank, of which he was not at the time aware. At the same time the extreme left fell back by Tremmen on the way to Brandenburg.

The cavalry of the east division advanced close up to the Weinberg, but received a heavy fire from the battery posted there. The Cuirassier brigade was then attacked by the Uhlans but without effect, until taken in flank by the Hussar regiment which had been carefully brought

up on the right, sheltered by a slight undulation in the ground. The east cavalry, however, presently advanced again, accompanied by a battery which forced that of the enemy to retreat. The Uhlan brigade protecting this movement was brought to a stand and forced to receive a charge of the Cuirassier brigade, which caused it to fall back. It still showed a front however, until it joined the infantry on and to the right of the road to Etzin. Here a final attempt was made close to the Hebensberg to deter the enemy's retreat, but the infantry, forming battalion-squares, opened such a tremendous fire that a further advance was impossible, and the west division continued its retreat covered by a battalion and a battery on the Belvedere and the cavalry in the plain. At this moment the "halt" was sounded, and the movements were discontinued.

Comments.

The first subject for remark in both these manœuvres is the turning movement, as naturally employed now by German tacticians as the line-formation has hitherto been by ourselves. Success is always a favourable plea, and this movement has undoubtedly been successful beyond measure during the more modern campaigns, and I am afraid that this has been the means of leading us to favour it more strongly than it deserves. We are told by high military authority that a flank-attack should not be attempted except by a superior force, and I think that late experience has strongly confirmed this view. On every occasion almost, with the exception of Trautenau, in 1866, these turning movements, which lead necessarily to a very considerable extension of front, have been made with superior forces, and on this one exception the appearance of a regiment unexpectedly on the flank, caused the retreat of the whole line. With the examples we have before us, we may know pretty surely that these are the tactics likely to be employed against us, and that as we shall presumably be oftener on the weaker side, our task is rather to study how to meet these attacks than to practise such extended movements ourselves. Now that the defensive power of artillery is so much increased, this arm is able in a great degree to fill up intervals between bodies of infantry, as was done by the Corps artillery in the corps manœuvre acting between the first and second divisions, and thus takes the place of the bodies of cavalry formerly employed. This facilitates considerably the extension of infantry, and secures it up to a certain point, but beyond this it cannot be extended without danger. In the case before us the attacking front extended at one time from Seeburg on the left to Closterfelde on the right, a distance of 6,500 paces, one half of which was occupied only by the left-flank-detachment and by the cavalry division supported by two batteries, which might have been easily kept in check by the retention of Seeburg by a sufficient force, without materially weakening the main position or endangering the line of retreat. By this means also the heights already in possession of the enemy could have been flanked by artillery fire. The subsequent manœuvre is a still more striking case: here the attacking front was no less than 12,000 paces in extent, and nearly the whole of this defended naturally by impassable ground. No attempt,

as it happens was made by the defending force to meet the turning movement on its right, probably because of its numerical inferiority; but the easy retention of the first and second columns of the left, warrant us in supposing that had the main body of the west division been carried to Falkenrehde, and fallen upon column No. 3 after the latter had crossed the Wublitz-Graben, the result would have been disastrous. On this point, I think we may at least conclude that, should the defender be fully informed of his opponent's movements, as he ought to be, he need never fear being outflanked unless he be the victim of a very considerable numerical inferiority. Otherwise he has only to follow the example set him, extending with his opponent, and seizing the moment he judges most opportune for a vigorous stroke upon his weakened line.

Infantry.

In the action of the artillery we notice the system of combined movements of masses developed to its greatest extent. The artillery divided into certain parts, according to the formation of the columns, is never subdivided, except perhaps for momentary action, and is always in front, preparing for the advance and final blow, as it were, which can now only be dealt by infantry as an auxiliary implement after the way has been thoroughly prepared for it. Following rapidly each retrograde movement of the enemy, it loses no time in preparing for a further attack, closing in as the enemy's threatened flank is withdrawn, until every gun is brought to bear effectively on the final position. When once this period is arrived at, patience alone is required to allow the enemy to be completely crushed, in spirit as in body, before launching the combined and final attack. The former strength of the artillery attached to a corps, which was 12 foot and 3 horse batteries, was considered insufficient to carry out this work effectually, and has been increased by two foot batteries; and no movement of the united corps is considered complete unless every gun is in action. It is remarkable that such implicit confidence should be placed in the artillery now as to employ it in lieu of infantry, for it is only since the campaign of 1866 that it has been considered safe to venture it away from infantry at all. Now, few German artillerists will allow that guns can be in any possible danger, whatever their position, unless attacked unawares. We can hardly adopt this as a maxim, however, for the experience of the Germans has been rather one-sided, unless we take the evidence of the campaign of 1866, in which case we see that the Austrian artillery, which was certainly then far superior to theirs, and is so, I consider, still, was not able to hold its own against infantry in extended order, and I do not think any artillery can.

Cavalry.

The collecting of the whole of the cavalry, with the exception of regiments attached to divisions or columns, into brigades worked together on the extreme flank, shows an appreciation of the true employment of cavalry in line. To recall the whole of the advanced chain which has been feeling the way of the army, and to form it into a coherent mass, is one of the first cares for a Commander on coming into

contact with the enemy. There are only two flanks, and the one is sure to claim advantages for the action of cavalry over the other, and when once this is determined, it becomes the business of the cavalry Commander to keep his force as far as possible out of fire and to launch it when a favourable moment arrives. In the manœuvre of the 10th, great expertness was shown in the movements of the cavalry masses, and the taking of the Cuirassiers in flank by the Hussars from a sheltering fold of ground at the commencement of the retreat was superb, but the subsequent movements of the cavalry of the east division showed a disregard for both artillery and small-arm-fire which must have been fatal to it. It may be argued that it was acting upon the supposition that the retreating force must be demoralized. The retreat, on the contrary, was conducted with the greatest order and steadiness. Assimilation to real war is a sufficiently hard task when only the results of actual movements, attacks, &c., have to be taken into consideration in a material point of view, but if the morale is to enter also into the calculations, it becomes impossible. Again, were even this to be considered, it would have told more severely upon the cavalry itself, for experience has shown us that a body of cavalry which has once charged well home, is not fitted for further employment for a considerable time, whereas in the present case four charges were given in quick succession, and the cavalry was all the time under artillery, and latterly under small-arm-fire as well.

Infantry.

The adoption of some modified formation for the attack of exposed positions by infantry, has been a question for some years past, and one which has not yet been definitely decided. The various evidence relating to the last war has, however, been sifted, and a formation suggested as likely to meet the requirements of the present day. It was found during the war, and especially in very open ground, that a speedy reinforcement was required for the extended line, and the supports in close order in rear had to be broken into, in order to supply it. This caused very considerable delay, and a great deal of confusion, as must necessarily be the case; and the formation proposed to remedy these defects provides for a second extended line, which can reinforce the front one as required. This can be extended to any degree by having a third, or even a fourth line in skirmishing order, and the former we have seen was employed by the Emperor Francis Joseph's regiment for the attack on the Carpzow wood. These are followed by the supports in close order, in whatever formation is suitable to the ground, and the remainder of the battalion follows, generally in half battalion formation. The advance is executed by a series of rapid movements to the front, and then a rest, the whole lying down, as was adopted by one division of this same corps in the attack upon le Bourget. In perfectly open ground such a formation is undoubtedly suitable, providing as it does for the gradual reinforcement of the foremost line, it allows the supports to keep further to the rear, and to move out of their positions if necessary, in order to take advantage of any neighbouring cover. Where the ground also is at all sloping towards the enemy's position, it pro-

vides two tiers of fire, the second line firing over the heads of the first. In wooded or broken ground, however, I do not think it would be possible to maintain these lines distinct for any length of time, and the men destined for ultimate reinforcement would crowd the foremost line long before they were required. The method of advancing rapidly and lying down at intervals is very good in open ground, but if perfectly free from undulations, which is rarely the case, I should not consider it expedient to stop again after arriving within 200 paces of the position. A careful and rapid fire of considerable duration from the last pausing-place, and then the final rush, would, I think, be a greater economy of men than three more halts, which there would be if these were made at about every 50 paces. Some such formation as the above is undoubtedly required to be practised, and some similar method of attack, but the occasions for their use should be left entirely to the discretion of Officers in command of companies, to whom too great latitude cannot be allowed in these matters. In the thorough training of these Officers in a knowledge of ground by means of theoretical study, by maps, and constant practice in varied ground in the field, lies the first earnest of success in the attack of a position by infantry.

In conclusion, I would venture to point out one other circumstance to be remarked in these Manœuvres. I have already mentioned that the cavalry exposed itself considerably to the fire both of artillery and of infantry in what appeared an unwarrantable manner, but this seems to have been done on principle. With the infantry, however, it is different; no German Officer probably can be found who would advocate the old plan of a steady advance without regard to cover or the enemy's bullets, and yet such advances were made only too often. A disregard of fire and of cover, which could vie with that of our most strictly parade-drilled troops was displayed on several occasions. The fire also was most hurried, and a want of care in the aim taken, told little for the "fire discipline," of which we have read and heard so much. This was accounted for in the following manner; in order to suit the time of the visit of the Emperors to Berlin, these greater manœuvres were being executed before the lesser ones with mixed arms had been carried out, instead of after them as should have been the case. This, in the eyes of the German Officers, fully accounted for unsteadiness, and they regretted that it should have been done even in such an exceptional case. That this view is correct there can be little doubt. With troops which manœuvre together yearly, the preliminary tactical training cannot be dispensed with; we may easily therefore draw the inference I think, that it can be much less dispensed with with troops which are brought together for the first time on the eve of operations on an extensive scale.

A BRIEF SKETCH OF THE SYSTEM OF OFFICERING THE PRUSSIAN ARMY.

By Lieut. CHARLES E. H. VINCENT, 23rd Royal Welsh Fusiliers.*

Modes of Entering the Army.

THERE are two ways by which, in time of peace, a Prussian Officer can obtain his first commission:—

(*a.*) By passing the required examination in general subjects, serving a short time in the ranks, and afterwards as a Non-commissioned Officer, and qualifying in the theoretical knowledge of his profession, after a nine months' course of study at the School of War.

(*b.*) By passing this latter examination direct from a special superior class of the corps of cadets.

The *modus operandi* in case (*a*) is as follows:—

The aspirant to a commission in the Army presents himself to the Colonel of the regiment to which he hopes eventually to belong. Should his birth be such as to render him a suitable comrade for the Officers of the regiment, and his parents be prepared to provide sufficient means for him to live on the same standard of expenditure as his brother Officers, and should his testimonials as to conduct and character be satisfactory, the Colonel gives his consent to his coming into the regiment, provided the medical inspection puts no obstacle in the way, and the candidate pass the "Fähnrich's" ("Ensign" he can't be called, for "Ensign" in our Army means a Commissioned Officer, on one roster with the Lieutenants, corresponding to the second Lieutenant of the Prussian service) examination in general subjects—such as French, English, geography, history, Latin, Greek, mathematics, and drawing—which is held periodically under the auspices of the Government. This examination passed, the "Fähnrich" provides himself with the uniform of a private soldier, though made of better cloth, and he is allowed to wear his sword-bayonet in the streets, &c., with an Officer's sword-knot attached thereto. He joins the regiment, is attached to a company, and is drilled in every respect as a common soldier. In some regiments he must live for a week in the barrack-room; but as a general rule he is allowed a room to himself during the entire time. He is made an honorary member of the Officer's mess (though never omitting to pay his superiors every mark of military respect), in order that they may have additional facility for observing the character of their future comrade.

As regards absence from barracks, the "Fähnrich" is bound by the same restrictions as the private soldier, if he be serving in the ranks, or as the Non-commissioned Officer, if he be doing duty as such. His morals are under the care of his Captain; and the Colonel, knowing

* Reprinted from a pamphlet circulated privately in January, 1871.

exactly the funds he commands, can judge if his habits of life are beyond the length of his purse. The "Fähnrich" receives the pay of the rank with which he is doing duty.

Having thoroughly mastered every detail of his drill and duty as a private, he is passed through the several grades of the non-commissioned ranks. He must perform *every* duty *at least* once himself, after which he may pay a substitute. The "Fahnrich" is then sent on to the School of War (Krieg's Schule), organized on much the same principle as our military academies, in companies with professors, superintendents of military discipline, and student under Officers and Corporals. Here during a course of nine months, working nine or ten hours a day, he is taught the theory of war, fortification, military history, surveying, &c., &c., but beyond riding-classes there is no military drill. For the slightest offence, whether of idleness or of conduct, the "Fähnrich" returns for a year to the ranks of his regiment, thus losing a year of his career. The severity of the discipline at the Krieg's Schule passes all comprehension; a minute late, an illicit correspondence, and the merest infraction of the letter of the law, is followed by the severest punishment. Should the "Fähnrich" be suffering on entering from venereal disease, he returns forthwith to his regiment, and in like manner if he contracts it during his residence at the institution. At the end of nine months the examination is held; those that pass, return to their regiments to await a vacancy in the subaltern ranks, and, although retaining the old uniform, wear an Officer's sword; those that fail, are not allowed another trial. The "Fähnrich" who has passed the School of War, does duty as a second Lieutenant, and a vacancy occurring, the Colonel assembles the Officers, and inquires if they have any objection to accept him (the "Fähnrich") as a comrade. Should he have made himself in any way obnoxious, or should he have proved himself an unworthy companion, one who would never be to the credit of the regiment, the Colonel would recommend him for his commission, but append thereto a request that he shall be transferred to another regiment on obtaining his promotion. The transfer he may also obtain at his own request; but should all be well, he will obtain his commission forthwith in the regiment.

(*b.*) A cadet first enters the corps at the age of ten, but beyond an hour's drill or gymnastics daily, except in the higher classes, the education differs very slightly from that of an ordinary public school. Beyond the first class, is a special military class, in which the same subjects are taught as at the School of War, and from which the Officer's examination may be directly passed. But if the cadet leave the corps before he reaches this class, his military route differs in no way from that of the private individual, and even those who pass from the special class have to learn practically the duties of a soldier and Non-Commissioned Officer. Commanding Officers, as a rule, prefer those Officers who have not been cadets, as their education and line of life has extended over a wider scope, and also because the discipline of the cadets having been so terribly severe, they generally break away when the curb is loosened. The only exceptions for Fähnrichs not passing the School of War is in favour of those who have passed the

"Abiturienten" examination (the Bacchélaureat of France, the Degree of England), or who have resided for a year at a university.

Instruction of Officers.

The Officer, when once he has obtained his commission, is freed from all further theoretical instruction, but in garrisons, voluntary classes are formed. Each year every Prussian Officer under field rank has assigned to him a practical and a theoretical task.

The practical task is as follows:—The Officer is warned over night that on the morrow he will have to carry out his practical exercise, for which purpose he will be on parade at such an hour. Here he finds the detachment awaiting him which is to be at his orders. Sealed instructions are handed to him, on which he forthwith acts. But an hour before, another Officer has left the barracks to carry out also his practical task, with instructions, the reverse of those of his unknown opponent.

For instance, one Officer is informed that his party forms the advanced guard of a force attacking Berlin from the north; his directions are to feel well forward for the enemy, to find the best position for crossing the river, and, if necessary, to force a passage. His opponent has the command of the advanced posts of the defenders, and makes his dispositions accordingly. The parties are distinguished by the one wearing forage caps and shell jackets, and the other wearing full dress, and in the cavalry with lance-flags furled, and flying. At the time when a critic may be able to form an opinion on the superiority of the one's disposition over the other's, the Colonel, General, or some other superior Officer comes up, and decides for the victor. Both parties then unite, and publicly each Officer explains his dispositions, and the reasons for making them. The Colonel, or umpire, makes his remarks and awards praise or blame. It is obvious that as the whole matter goes before the superior authorities, and every Officer is anxious to appear to advantage in the eyes of the men, a spirit of emulation is excited, and as all the details are patiently explained to the men, they too take an interest in the result. The contending Officers, on their return home, draw up a complete military report of the proceedings, with a sketch.

The theoretical task is one which is awarded to each Officer yearly, and to perform which he is allowed a time in proportion to the subject.

The subjects are infinite: invasion of different countries; army organisation, sanitary and commissariat arrangements in the field; training horses, &c., &c.; in which full freedom and liberty of speech are allowed; and, however wide the work may be from the mark, it must accomplish its purpose of developing habits of thought and study. The task when completed is read by the Colonel,—the Generals of Brigade and Division each appending his remarks,—and is then returned to the author. Those of special excellence go before yet higher authorities, and even to the Emperor himself.

Examination for Promotion.

There is none for any commissioned rank in the Army.

Relative Merit of Officers.

The relative merit of every Officer, from highest to lowest, is known to the general staff at Berlin. Each year a confidential report is made by the Colonel of the regiment and the General of Brigade, on every Officer under their command; that of subalterns is based on the testimony of their Captains. Extracts from these reports are entered at head quarters in a "Conduitten Liste." On the commencement of a campaign, those Captains whose military proficiency is of an inferior order, are left behind with the Reserve, or speedily disposed of as commanders of an unimportant post. The same principle works from General to junior second Lieutenant. Those of ability are pushed on: those of inferiority kept in the background. In every regiment there is one Major, but should he be unfit to assume the command of a regiment he is passed over "*sans mot dire.*" The Majors of the Army are on one list for promotion, whereas the promotion of the junior Officers goes regimentally. Now, a Major seeing one junior after another get the command of a regiment, speedily appreciates his incompetence, and retires. Thus the quality of the Colonels and Generals is accounted for.

Promotion for Merit in Peace.

An Officer who shows marked ability in any particular subject or line, is pushed on very rapidly by the following means. His commission as second Lieutenant bears date August 10th, 1869; he is drafted into a regiment, where the senior second Lieutenant would be his junior; he therefore takes his place at the top of the list, and obtains the first vacancy for promotion, and so on again.

Staff or Regimental Employment.

Except in special cases, which are by no means rare, Officers are not eligible for staff or regimental employment until they have had three years' service.

Staff College,

the equivalent for which is the "Krieg's Acadamie," to enter which an Officer can try after three years' service. The course of study is three years. At the end of each year, should an Officer not come up to the standard, he will return to his regiment, by no means injured in reputation, but rather with a character for a desire to improve. Those who pass, are sure of staff employment, each according to his line. It is needless to add, that visiting privately the defences, lines of invasion, &c., of foreign countries,—however peaceful the existing relations,—finds employment for considerable numbers.

Leave of Absence.

Each Prussian Officer receives, as a rule, from six weeks to two months' leave of absence during the year—*i.e.*, about a fortnight between

the winter and spring-drills, about three weeks in the middle of summer, between the spring-drills and summer-manœuvres, and about a fortnight between the summer-manœuvres and the winter-drills. Of course never more than half the Officers are absent at one time, and if an Officer desire, for some well substantiated reason, to have the whole at once, or the accumulation of two or three years, he can do so.

Pay, Regimental Details.

Each Officer receives his pay direct from the Paymaster, with monthly deductions for messing, tailors', shoemakers' bills, widows' fund, band, &c., &c.; and there are also many regimental details in points of honour, etiquette, &c.; many regimental committees, so perfectly incompatible with the British service, that I refrain from entering into them, but only add, that as the Colonel knows the income of each of his Officers, he can check any undue expenditure.

Connection with Men.

The connection of the Prussian Officer with his men is very close. He drills them, gives lectures to them, superintends their every action; an Officer during the winter months gives lectures to them on their profession, on geography, military history, &c., to which classes the voluntary attendance is very large. In fact, the Officer is constantly showing how thoroughly he is the master of his profession, and by education, birth, and breeding, the superior of the soldier.

Social Position of Officers.

In the Guards, the majority are of noble families, but in the Line many are gentlemen only by virtue of their cloth and education; but so high is the standard of honour among them, that I recently heard a very animated discussion as to whether it was consistent with the dignity of an Officer to take a rifle from a private in action for the purpose of killing, by superior skill, one of the enemy whose death would be of importance. Some argued that it was the duty of every Officer to inflict as much injury as possible on the enemy, and being a better shot, he would be to blame if he did not adopt the above-named course. However, a very large majority decided that it would be a breach of international honour and etiquette to depart thus from your position as an Officer.

The Journal

OF THE

Royal United Service Institution.

VOL. XVI. 1873. APPENDIX.

PROCEEDINGS OF THE FORTY-SECOND ANNIVERSARY MEETING.

THE FORTY-SECOND ANNIVERSARY MEETING of the Members was held in the Theatre of the Institution, on Saturday, the 1st March, 1873.

The Most Hon. the MARQUIS OF LANSDOWNE, Under Secretary of State for War, in the Chair.

I. The Secretary read the Notice convening the Meeting.

II. The Secretary read the Minutes of the Forty-first Anniversary Meeting.

III. The Annual Report of the Council was read as follows:—

1. THE COUNCIL have much pleasure in laying before the Members their Forty-second Annual Report.

MEMBERS.

2. The number of Members who joined the Institution during the year 1872, is three hundred and thirty-six, being an increase of ninety-nine over the number of the previous year. The loss by death is one hundred and four; and thirty-eight Members withdrew their names. The net increase in the number of Members is, therefore, one hundred and ninety-four.

A detailed statement of the changes in the list of Members, and a tabular analysis of the past and present state of the Institution, will be found on pages ix and x.

FINANCE.

3. The usual Abstract of the Yearly Accounts, as audited on the 11th February, will be found on the following page.

GENERAL ABSTRACT OF THE ACCOUNTS OF THE ROYAL UNITED SERVICE INSTITUTION, FROM 1st JANUARY to 31st DECEMBER, 1872.

EXPENDITURE.

	£	s.	d.	£	s.	d.
Secretary's Salary	250	–	–			
Ditto Lodging Allowance	50	–	–			
				300	–	–
Librarian's Salary...				150	–	–
Acting Clerk's Salary				70	4	–
Servants' Wages				431	19	2
Ditto Clothing...				46	2	–
Insurance...				11	5	–
Ground Rent				200	7	3
Fuel				51	19	–
Lighting				47	8	3
Annuity to John Pitt				20	–	–
Assessed and Income Taxes...				69	15	7
Parish and Water Rates				100	–	8
Artificers				108	5	3
Museum				153	3	3
Library, Reading, and Topographical Rooms				191	12	5
Advertisements				133	17	2
Printing Circulars and Stationery				218	9	10
Lectures				28	6	–
Journals, including Annual Report and List of Members				974	12	10
Postage { Journals	131	16	2			
Postage { Letters...	52	4	10			
				184	1	–
House Expenses and Sundries				50	18	10
Cash repaid to Agents				12	10	–
Charges from ditto				–	12	2
For £365 16*s.* 4*d.* India 5 per cent. Stock				400	–	–
Balance (Income) { Bill at 90 days due 16th Feb. ...	11	–	–			
Balance (Income) { At Bankers	144	8	–			
				155	8	–
				£4,110	17	8
For £812 10*s.* 10*d.* 3 per cent. Consols, Life Subscriptions				750	–	–
Balance (Life) { Bill at 90 days due 16th Feb. ...	27	–	–			
Balance (Life) { At Bankers	86	10	–			
				113	10	–
Total Income and Life				£4,974	7	8

RECEIPTS.

	£	s.	d.	£	s.	d.
Balance at Bankers, 31st December, 1871				156	6	1
Annual Subscriptions, at 10*s.*	359	–	–			
,, ,, above 10*s.*	2,172	19	6			
,, ,, arrears	71	10	–			
,, ,, advance	10	1	–			
Increased Subscriptions, at 10*s.*	7	–	–			
				2,620	10	6
Entrance Fees				336	3	–
Donations				2	12	–
Dividends				264	10	1
Interest on Exchequer Bills				20	7	2
Government Grant				600	–	–
Sale of Journals				100	18	8
Miscellaneous Receipts				9	10	2
				£4,110	17	8
Balance of Life Subscriptions at Bankers, 31st December, 1871 ...				150	10	–
Life Subscriptions				713	–	–
Total Income and Life				£4,974	7	8

Examined and found correct, 11th February, 1872.

J. E. A. DOLBY
TOB. G. RIDGWAY } Auditors.
THO. SMITH

T. D. SULLIVAN, Accountant.

Estimate of Receipts and Expenditure for the Year 1873.

Expenditure.	£	s.	d.	Receipts.	£	s.	d.
Secretary's Salary and Lodging allowance	350	–	–	Balance at Bankers, 31st Dec., 1872	263	–	–
Librarian and Accountant's do.	200	–	–	Annual Subscriptions:			
Acting Clerk's do. ..	70	–	–	£ s. d.			
Servants' Wages	450	–	–	At 10s. .. 350 – –			
Ditto Clothing ..	50	–	–	Above ..2,500 – –			
Insurance	11	5	–		2,850	–	–
Ground Rent	205	–	–	Entrance Fees	250	–	–
Fuel	100	–	–	Dividends	280	–	–
Lighting	60	–	–	Sale of Journals	100	–	–
Annuity to John Pitt ..	20	–	–	Government Grant ..	600	–	–
Assessed Taxes & Income Tax	100	–	–				
Parish and Water Rates	110	–	–				
Artificers, Repairs, &c. ..	150	–	–				
Museum	200	–	–				
Library and Topographical Departments	200	–	–				
Advertisements	150	–	–				
Printing Circulars, & Stationery	150	–	–				
Lectures	50	–	–				
Journals	1,000	–	–				
Postage of Journals ..	170	–	–				
Postage	60	–	–				
Printing Annual Report and List of Members ..	80	–	–				
Miscellaneous	60	–	–				
Balance ..	351	15	–				
Total.. ..	£4,348	–	–	Total.. ..	£4,348	–	–

Audited and found correct,
THO. G. RIDGWAY } Auditors.
THO. SMITH

The Council have increased the Salaries of the Secretary and Librarian by £50 each.

Life Subscriptions.

4. Life Subscriptions amounting to £750, including £150 10s., not invested last year, have been invested in Three per Cent. Consols.

Capital Account.

5. The funded property of the Institution on the 1st January, 1873, was £8,926 12s. 4d., as compared with £7,748 7s. 2d. on the 1st January, 1872.

Tenure of the Premises.

6. In the last Annual Report, the Members were informed by the Council that they were making inquiries with regard to building sites in this neighbourhood, and likewise as to the cost of a building suitable to the purposes of the Institution.

In making these inquiries, the Council were assisted by the late Mr. Marrable, an architect highly recommended, and well acquainted with this part of London. No suitable site could be found at a lower price than about £21,000; adding the cost of a new building and the necessary expenses of moving, fittings, &c., the total expense of placing the Institution in proper working order in a new position, cannot be estimated at less than £37,000.

On June 13th, a letter was written to the Chancellor of the Exchequer reminding him of his promise to help the Institution when the proper time arrived, and stating the large expenditure which must be incurred to establish the Institution in a suitable position, should its removal be insisted on by the Government.

In reply, a letter dated September 30th, was received from the Lords of the Treasury, withdrawing the notice to quit in April, 1873, and allowing the Institution to retain these premises "on the terms of the existing arrangement."

With the hope of obtaining some definite information as to the future disposal of the Crown-lands in this neighbourhood, a deputation of the Council had an interview on November the 23rd with Mr. Gore, First Commissioner of Woods, &c., who informed them that the whole question depended upon the course that might be taken by the House of Commons with regard to a strip of land on the Embankment, respecting which difficulties had arisen between the Metropolitan Board of Works and the Government; and that until the ownership of the ground had been decided, the Government could make no definite arrangement as to the future.

Lectures and Journal.

7. In addition to the ordinary Lectures and Evening Meetings last year, the Council granted the use of the Theatre to the Officers of the Rifle Volunteer Corps for five Special Lectures. These Lectures were so well attended that the Council have approved of two courses of Special Lectures being given during this year; one course to the Rifle Volunteer Officers, and the other to the Officers of the Volunteer Artillery.

The thanks of the Council are eminently due to all who gave lectures or read papers during the last session in the Lecture Theatre, where questions of the highest importance were considered and discussed, previous to publication in the Journal. Since the prosperity of the Institution depends in a great measure on the estimation in which the Journal is held, it is satisfactory to find kindred Institutions, both at home and abroad, desirous of an interchange of publications; and the marked increase of new Members may fairly be attributed to the Journal having become more widely known and better appreciated among the Officers of the two Services.

Library.

8. Four hundred and seventy volumes were added to the Library during the past year; of these, 209 were purchased and 263 presented. Among the latter, the following are the most noteworthy:—

By the Austrian Government—
Mittheilungen über Gegenstände des Artillerie- und Genie-Wesens.

By the French Government—
Revue Maritime et Coloniale.
Six Volumes on Military and Naval subjects.

By the Italian Government—
Rivista Militare.
Rivista Marittima.

By the Netherlands Government—
Six Plates of Artillery Equipment.
Twenty Volumes on Military subjects.

By the Prussian Government—
Archiv für die Artillerie- und Ingenieur-Offiziere des Deutschen Reichsheeres.
Militärische Blätter.
Militair-Literatur-Zeitung.

By the Russian Government—
Engineering Journal.

By the Spanish Government—
Memorial de Ingenieros.
Thirteen Volumes on Military subjects.

By the Swiss Government—
Fifteen Pamphlets on Military subjects.

By the United States Government—
Seven Volumes on Military and Naval subjects.

The exchange of Journals with Foreign Governments, and with various Scientific Societies in this, and other Countries, has been continued. Three hundred and ten Volumes of duplicate books were either presented to other Societies or sold.

The Library now contains 15,761 volumes.

Topographical Department.

9. The Secretary of State for War has presented Photographs and Lithographs of Guns, Casemates, Shields, Targets, &c.

The Institution has also received from the Lords Commissioners of the Admiralty, Charts, Sailing-Directions, &c.

The French Government have presented some Maps, &c.

Museum.

10. The importance of the Kriegsspiel as a means of military education having been recognized in this country, the Council procured from Berlin, through the kindness of General Walker, C.B., Military Attaché there, sets of the Kriegsspiel and of the Festungs Kriegsspiel. The former game has created much interest amongst the Members, and has been played in the Theatre of the Institution. It has now been generally introduced into the Service.

Amongst the additions to the Museum, the following may be noted, viz.:—

Topographical Model Room.—An elaborate Model of Paris, with the German lines of investment, by Herr Walger, of Berlin. Horizontal scale of model, $\frac{1}{80,000}$, vertical scale, $\frac{1}{8000}$.

Naval Model Room.—Half-block Models of H.M. Ships "Raleigh," "Hotspur," "Cyclops," and "Snake," made by permission of the Lords of the Admiralty, in H.M.'s Dockyards, at the cost of the Institution.

Gun-Model Room.—Models (quarter-size) of the 35-ton Gun, 8-in. Howitzer, and 9-pr. M.L. Field Gun, with their respective Shot and Shell.

Armoury.—Sword of Honour, voted by the Patriotic Fund at Lloyd's to T. Pendergras, Esq., commanding the H.E.I. Company's ship "Hope," one of the fleet which, on the 15th February, 1804, drove off a squadron of French men-of-war under command of Admiral Linois, in the "Marengo" of 84 guns, as recorded in the "London Gazette" of August 11th, 1804. This sword was presented to the Museum by Major J. G. Clarke, late, 68th Light Infantry, a Member of the Institution.

The thanks of the Council have been tendered to the Secretaries of State for War and for India, to the Lords Commissioners of the Admiralty, and to the several donors for their respective contributions.

Vice-Patrons.

11. The Council have to record the deaths of the following Vice-Patrons, viz.: Admiral of the Fleet Sir Thomas J. Cochrane, G.C.B., and Field Marshal Sir George Pollock, Bart., G.C.B., G.C.S.I., Constable of the Tower.

Sir Thomas Cochrane entered the Navy in 1796, and saw active service on various stations up to June, 1805, when he was promoted to the command of the "Nimrod," sloop of war. In 1809, when in command of the "Jason," he captured "La Favorite," French national ship, and assisted in reducing the Danish West India Islands. In the same year Captain Cochrane served at the capture of Martinique and the Saintes, and was present at the operations in the Chesapeake and on the Coast of Georgia. In 1824, he was nominated Governor and Commander-in-Chief of the Colony of Newfoundland, which command he retained till 1834. In 1842, he hoisted his flag in the "Agincourt," as second in command on the East Indies and China

Station, where from 1845 to 1847 he filled the post of Commander-in-Chief; in the latter year he was created a K.C.B. Sir Thomas Cochrane became a Vice-Admiral in 1850, and was Commander-in-Chief at Portsmouth from 1852 to 1856, in which year he attained the rank of Admiral. In 1860, he was created a G.C.B., and in 1865 was appointed Admiral of the Fleet.

Sir Thomas Cochrane joined the Institution in 1832, and was elected a Vice-Patron in 1863.

Field Marshal Sir George Pollock, Bart., G.C.B., G.C.S.I., Constable of the Tower.

Sir George Pollock entered the Military Service of the East India Company in 1803 when scarcely eighteen years of age; was present at the storm and capture of Dieg in 1804; at the gallant but unsuccessful attempt to carry Bhurtpore by assault in 1805; and at the close of that year commanded the Artillery with Colonel Ball's detachment, sent in pursuit of Holkar. In 1816, he commanded the Artillery with General Wood's force in the Nepaulese War. In 1824, having attained the rank of Lieutenant-Colonel, he was nominated to command the Bengal Artillery attached to the force under Sir Archibald Campbell, proceeding to Rangoon, and for his services in that campaign was nominated a Companion of the Bath. In 1841, having attained the rank of Major-General, he was selected by the late Sir Jasper Nicolls to take command of the troops proceeding to Peshawur, in the hopes of recovering our position in Affghanistan. An immediate advance on Jellalabad to relieve Sir Robert Sale and the British Force shut up there being found impossible, General Pollock and his troops were forced to remain inactive in the neighbourhood of the Khyber Pass until the end of March, 1842. Having forced the pass by a series of brilliant and skilful operations, Sir George Pollock marched to the relief of Sir Robert Sale and his intrepid garrison, defeated the Affghan Forces and entered Cabul on the 17th September. General Pollock having been joined by General Nott, led the united army safely back to India, through those formidable passes which had so long delayed his progress. For these brilliant services, he was rewarded by being nominated a Grand Cross of the Bath, and was presented with a valuable sword by Shere Sing, ruler of the Punjaub. Sir George Pollock also received the thanks of both Houses of Parliament, the Freedom of the City of London, and a pension of £1,000 per annum from the Directors of the East India Company. In 1843, he was appointed Envoy at the Court of Oude, and in 1844 a Member of the Supreme Council of India. On his return to England he was nominated by the Crown one of the Directors of the East India Company. Sir George Pollock was one of the first who were decorated with the knighthood of the Star of India, and was created a Baronet on the 20th March, 1872, with the title of Sir George Pollock of the Khyber Pass.

On the death of Field Marshal Sir John Burgoyne, Sir George Pollock was appointed his successor as Constable of the Tower of London.

Sir George Pollock joined the Institution in 1849, was elected a Member of Council in 1850, a Vice-President in 1855, and a Vice-Patron in 1870.

The Council have elected Admiral of the Fleet, Sir Houston Stewart, G.C.B., a Vice-Patron of the Institution.

Vice-President.

12. The death of Colonel Sykes, M.P., F.R.S., deprives the Institution of one of its earliest Members. As Member of Council and as Vice-President he took an active part in the management of the affairs of the Institution, and was ever ready to further its interests.

The Council have elected General Sir William J. Codrington, G.C.B., a Vice-President of the Institution.

Honorary Members.

13. During the past year the Council elected His late Majesty the Emperor Napoleon III, the Prince Imperial, and the Prince Hassan, second son of the Viceroy of Egypt, Honorary Members of the Institution.

Several Officers of foreign services were elected Honorary Members during their stay in this country.

Corresponding Members of Council.

14. It will be gratifying to the Members of the Institution to learn that the number of Corresponding Members of Council has increased from 334 to 349.

The Council thank the Corresponding Members for their past services, and express a hope that they will continue their efforts to make the advantages of the Institution more widely known.

Conclusion.

In concluding this, their Forty-Second Annual Report, the Council point with satisfaction to the marked increase in the number of the Members, to the sound state of the finances, and to the high estimation in which the Institution is held by the Services and by the country.

STATEMENT OF CHANGES AMONG THE MEMBERS SINCE 1ST JANUARY, 1872.

	Life.	Annual.	Total.
Number of Members, 31st December, 1871 ..	951	2,971	3,922
,, ,, joined during 1872 ..	73	263	336
	1,024	3,234	4,258
Changed from Annual to Life	+6	−6	
	1,030	3,228	4,258
Deduct—Deaths during 1872 .. (Life 21, Annual 83)			
Withdrawals .. (Annual 38)			
(Life 21, Annual 121)	21	121	142
Number of Members on 1st January, 1873 ..	1,009	3,107	4,116

Tabular Analysis of the State of the Institution,
To 31st of December, 1872.

Year. 1st Jan. to 31st Dec.	Annual Subs. received.	Entrance Fees.	Income (from all sources).*	Life Subs. received.	Amount of Stock.	Invested in the purchase of Books, &c.	No. of Vols. in Library.	No. of Members on the 31st Dec.	Number of Visitors
	£	£	£	£	£	£			
1831	654	..	654	1,194	..	..	..	1,437	..
1832	1,146	..	1,146	973	..	..	..	2,699	..
1833	1,405	..	1,450	692	..	..	..	3,341	..
1834	1,500	..	1,549	583	1,100	..	..	3,748	13,376
1835	1,480	..	1,574	366	2,430	40	..	4,155	8,537
1836	1,570	..	1,682	330	3,747	45	..	4,069	8,521
1837	1,549	..	1,747	222	4,747	180	..	4,164	10,907
1838	1,462	..	1,634	230	5,500	246	..	4,175	15,788
1839	1,399	..	1,565	168	5,500	292	..	4,186	16,248
1840	1,363	..	1,525	198	5,500	446	5,500	4,257	17,120
1841	1,450	..	1,643	186	6,000	243	5,850	4,243	19,421
1842	1,373	..	1,565	144	6,400	373	6,450	4,127	21,552
1843	1,299	..	1,494	140	6,700	237	7,000	4,078	27,056
1844	1,274	..	1,408	112	3,000	298	7,850	3,968	22,767
1845	1,313	..	1,466	228	1,500	127	8,100	3,988	21,627
1846	1,298	..	1,456	138	1,500	74	8,410	4,031	32,885
1847	1,314	74	1,502	132	1,700	37	..	4,017	38,699
1848	1,175	57	1,375	48	1,700	85	9,641	3,947	37,140
1849	1,176	72	1,375	84	1,150	58	..	3,970	33,333
1850	1,141	166	1,294	198	600	36	..	3,998	33,773
1851	1,136	131	1,292	66	666	34	10,150	3,188	52,173
1852	1,134	133	1,281	114	200	43	10,300	3,078	20,609
1853	1,243	319	1,684	264	528	41	10,420	3,251	25,952
1854	1,200	138	1,368	126	612	95	10,587	3,171	22,661
1855	1,159	107	1,289	120	653	55	10,780	3,131	14,778
1856	1,216	197	1,519	156	761	47	10,832	3,204	16,184
1857	1,258	176	1,937	78	1,038	40	10,960	3,168	12,755
1858	1,318	221	2,102	105	438	31	11,062	3,246	25,747
1859	1,526	195	2,277	512	946	70	11,320	3,344	28,739
1860	1,961	298	3,577	397	2,178	114	11,517	3,518	28,011
1861	2,122	305	2,899	266	2,846	99	11,812	3,689	23,296
1862	2,296	242	3,127	239	3,178	109	12,026	3,797	27,215
1863	2,379	218	3,100	405	3,583	143	12,296	3,847	18,150
1864	2,425	215	3,253	222	4,516	116	12,700	3,902	17,276
1865	2,435	154	3,467	235	4,804	137	13,000	3,895	18,253
1866	2,435	157	3,488	299	5,486	150	13,337	3,891	17,067
1867	2,431	141	3,467	208	5,732	140	13,800	3,823	17,211
1868	2,446	184	3,534	297	6,396	119	14,100	3,812	16,417
1869	2,368	165	3,485	238	6,653	232	14,669	3,792	15,947
1870	2,376	178	3,493	333	7,313	140	15,055	3,831	18,654
1871	2,455	237	3,677	538	7,748	202	15,501	3,922	19,420
1872	2,620	336	4,111	713	8,927	192	15,761	4,116	19,773

* Including Annual Subscriptions, Entrance Fees, Donations, Legacies, and Interest on Funded Property also the Grant from Government, commencing in 1857.

IV. Admiral THE EARL OF LAUDERDALE, K.C.B.—

I beg to move the first Resolution, viz., "That the Report now read be adopted and printed for circulation amongst the Members." In doing so, I think I may congratulate the Members on the improved state of the Revenue on all points. I see at the end of the Report, a tabular statement of the different items, from which it appears that on every point the Revenue has increased. The "Annual Subscriptions" have considerably increased. The "Entrance Fees," and the "Income from all Sources" have also increased. The "Life Subscriptions" are greater than they have been since the year 1831; and I believe the large amount of Life Subscriptions received that year, was owing to Officers paying Life Compositions on the first establishment of the Institution. They amounted in that year to £1,194, and they have been as low as £48; this year they stand at £713, which is, as I say, greater than any year since 1831. The "Amount of Stock" has also increased considerably. The amount "Invested in the purchase of Books" has not increased, but the number of books has increased; which is better. The number of Members has largely increased, and the number of Visitors had increased also. I think, therefore, that we may fairly say that we are in an improving state. I am happy to see by the Report that the Government have withdrawn the "notice to quit" which we received so unexpectedly. I hope that the noble Marquis will use his interest for us, and that if they take these buildings or the site from us, they will give us another. I think it cannot now be disputed that this is a most important public institution belonging to the country. Government and the House of Commons think nothing of giving money to buy plants, pictures, statues, and they build houses to put them in; and this is all for the recreation of the people. But here is an Institution, which no man will deny has now become of the greatest importance to the country, not for pleasure, but in case we ever get into difficulties with foreign nations, to teach us how to defend ourselves, and also the best modes of carrying on war. These questions are here publicly discussed by professional men; and there is no other Institution in the country in which it can be done. I therefore hope that the Government will think seriously before they turn us out of our present buildings, as if we were some common Institution of little or no value to the country. I beg leave to move the Resolution.

The Resolution, having been seconded by Lieut.-General WILBRAHAM, C.B., was put from the Chair, and was carried unanimously.

V. The names of the eight Members retiring by rotation from the Council were read as follows:—

Colonel H. HUME, C.B.
Major C. B. BRACKENBURY, R.A.
Colonel F. C. A. STEPHENSON, C.B., Commanding Scots Fusilier Guards.
Captain W. D. MALTON.
Colonel A. H. LANE FOX.
Colonel H. A. OUVRY, C.B.
Major-General Sir ANDREW WAUGH, Kt., F.R.S.
Rear-Admiral J. W. TABLETON, C.B.

Lieut.-General M'CLEVERTY—

My Lords and Gentlemen, I have great pleasure in proposing the second Resolution, viz. :—

"That the thanks of this Meeting be given to the Members of the Council who retire by rotation; and that the following Members be elected to fill the vacancies, viz. :—

Col. H. HUME, C.B.	For Re-election	Col. MAITLAND, Lieut.-Gov. Chelsea Hospital.
Col. STEPHENSON, C.B.		
Maj.-Gen. Sir ANDREW WAUGH, Kt., F.R.S.		Maj.-Gen. SCHOMBERG, C.B., R.M.A.
		Maj.-Gen. W. J. SMYTHE, R.A.
Rear-Adm. Sir LEOPOLD J. HEATH, K.C.B.		Col. Lord ELCHO, M.P.

and that the following names be adopted from which to select in the event of vacancies occurring in the Council, viz. :—

Lieut.-Col. Lord WILLIAM F. SEYMOUR, Coldstream Guards.
Capt. G. TRYON, C.B., R.N."

I am sure, my Lords and Gentlemen, that you will all join with me in the Resolution which I have just now moved, viz., "That the thanks of this Meeting be given to the Members of the Council who retire by rotation." We are all indebted to them most sincerely for the trouble they have taken in the interests of this Institution—an Institution so valuable and so connected with the best interests of the Service. After what we have heard from Lord Lauderdale, I can have nothing more to say, excepting that the Report which has been read this morning, shews the interest that the Members of the Council have taken in forwarding the interests of the Institution.

Captain WELLS, R.N., having seconded the Resolution,

Major BAYLIS, 36th Middlesex Rifle Volunteers, said—

Before the Resolution is put, I think I shall be in order in the few observations I have to make, with reference especially to that part of the Report which speaks of the tenure of the premises. I was present at the last Anniversary Meeting, when we were all of course naturally in a great state of anxiety as to whether we should be turned out of these premises or not. Since then we have received a letter withdrawing the notice to quit. But we must remember that we are liable at any time to receive a three months' notice. You are all well aware of the negotiation that has been going on for some time past between the Government and the Metropolitan Board of Works as to some land on the Embankment, and the result is, that an arrangement has been come to between them. But I do not think the Council can look to obtaining any site on the Embankment; a very large price has been paid for it, and we cannot look forward to obtaining a place there. I see the "Times" of to-day mentions a Society which has been promoted to erect a building to accommodate the London Learned and Scientific Societies, and which offers to provide a location for such Institutions as our own. I do not know to what extent the undertaking will be carried out, but I dare say you will permit me to draw your attention, and the attention of the Council, to it. The "Times" says:—"We understand a plan for providing a home and local habitation for such of these Societies as are not accommodated at Burlington House, has lately assumed a very definite form." It then goes on to say what they will do, and it probably might be worth the while of the Council to negotiate with that Society. I am sure no one can feel more than myself the value of this Institution, and the necessity that it should be put upon a permanent footing. I venture to make these remarks, seeing that the tenure under which we hold this Institution from the Government is of the most uncertain kind.

General Sir WM. CODRINGTON, G.C.B.—

With regard to the remark that has been made about the Metropolitan Board of Works and the agreement with the Government, I do not believe the Metropolitan Board of Works have any power of building at all on that ground; consequently it is no question whether they can charge a price or not. I think we may very safely conclude that they would not give us land at a less price than it is worth. What we want rather, and that is what I hope the Council of this Institution will enforce upon the Government, is, that we should receive assistance with regard to our funds.

The Resolution was then put from the Chair and was carried unanimously.

Lieut.-General HODGE, C.B.—

I beg to propose the third Resolution, which is—

"That the thanks of this Meeting be given to the Auditors for their valuable services; and that the following Gentlemen be re-elected Auditors for the ensuing year:—

Captain J. E. A. DOLBY (for re-election).
T. G. RIDGWAY, Esq.
THOMAS SMITH, Esq."

As these Gentlemen, I understand, are kind enough to perform, for us, the office of auditing our accounts gratis, I am sure that the least we can do is to give them a hearty vote of thanks.

The Resolution having been seconded by Captain GORE JONES, R.N., was put from the Chair, and was carried unanimously.

The CHAIRMAN then announced that the business of the Meeting was concluded.

The Chair having been taken by Rear-Admiral Sir JOHN HAY, M.P., Vice-Chairman of the Council,

Sir WILLIAM CODRINGTON said—

Mr. Chairman, The interest that is taken in this Institution in high quarters, is shown at almost every Anniversary, besides many other Meetings, by the presence of Members of the Government, connected with the Army and Navy. We have been favored very much by that circumstance. We are to-day favored by the presence of a noble lord bearing a very historic name, who holds a high office with regard to the Army, and who has lent us his countenance, in approval, I hope, of the proceedings of this Institution, and of the system adopted here. There can be no doubt that there are many questions which are, to use the common term, "ventilated" and discussed, in a Society of this sort, that cannot well be ventilated and discussed by a Government, which would naturally be loath to give an opinion on subjects which we are free enough to give an opinion upon, in this Institution. Therefore it is that this Institution is one of great value; and that it is appreciated, is shown by the tribute which has been paid to it by the heads both of the Army and Navy. I therefore ask you to return your best thanks to the Marquis of Lansdowne for his kindness in coming here to-day, not only as an individual, but as, we hope, representing the goodwill of the Government towards this Institution.

Vice-Admiral Sir FREDERICK NICOLSON, Bart., C.B.—

I have great pleasure in seconding the Resolution which has been so ably moved by Sir Wm. Codrington. I am sure it is needless to say anything further. As a Member of the Council, I may say this much, that we are always glad to find that those in high official situations connected with the two Services, are ready to lend us their countenance at our Annual Meetings.

The Resolution was then put from the Chair, and was carried with acclamation.

The Marquis of LANSDOWNE—

Sir John Hay, my Lords and Gentlemen, I hope that you will allow me to begin by saying that I am convinced that, if thanks are due from any one to-day, they are due from me and not to me. I esteem it a very great privilege to have been allowed by the Council of this Institution to take the Chair to-day. It has often occurred to me that one of the great advantages of public life—mine has been a very brief experience of such a life, but still it has convinced me of it none the less—is that it affords you opportunities of bringing yourself into contact with numbers of men, classes of men, associations of men, whom you would not otherwise have the privilege of meeting and knowing; and I can assure the Members present here to-day, that there is no association whose acquaintance I am more pleased to make, than that of the Royal United Service Institution. I say this not only as one of the general public who watch with an eye of approval and interest the energetic endeavours of this Institution, but I say it also as having the honour of being connected with one of the Public Departments, which will, I hope, continue always to preserve with this Institution, those amicable relations which I am convinced subsist between them. Added to this, I think I may congratulate myself upon having been allowed to occupy your Presidential Chair upon the occasion of certainly one of the most successful Meetings—I mean not so much in point of attendance, but successful in point of the condition of things which the Report discloses—that has ever been held. We have not only a very large and rapid increase in the number of Members of the Institution, but we have a very considerable financial increase as well; and I dwell with greater satisfaction upon this, because when I see the funded property of the Institution gradually increasing, it occurs to me that, should that unfortunate contingency which has been already referred to to-day, ever overtake us, the Institution will find itself with funds of its own whereby to second the effort which I believe will be made by any Government—whatever party it may belong to—to secure for the Royal United Service Institution a firm basis for the future. A reference to pledges which have been already given by persons holding high official positions in the present Government, is certainly reassuring on this subject; and I am convinced that those pledges were not only readily given, but will be honourably redeemed, when the day comes. On referring to your Report, I observe among the notices connected with this Institution, one notice upon which I wish to dwell for a moment, that is the mention of the names of those two gallant and distinguished officers who have passed away during the last year, I mean the names of Cochrane and Pollock. They need, I am sure, no recommendation from me; were it not that their predecessors are as numerous as they are distinguished, either of those names might be written up upon the walls of an Institution in which, like this, gallantry and intelligence, are held in high repute. I might mention the name of one other Member whom this Institution has lost, this time an Honorary Member, I mean his late Majesty the Emperor of the French. I am sure every Member of the Royal United Service Institution will join with me in reflecting that it is a source of congratulation to the Institution that among the many ties which bound the late Emperor of the French to this country, his Membership of this Institution was one. His tastes were eminently congenial to it, and I regret that it should have been ordained that he should continue so short a time to hold a place upon the muster-rolls of the Society.

Then, Gentlemen, having had the honour of filling the Chair to-day, I feel tempted to say a few words to you about your Institution itself, and I must confess that it is with some hesitation that I address myself to the task, because I run no inconsiderable risk of finding myself talking to you about a subject with regard to which you are very much better informed than I am. But there are one or two considerations that force themselves upon my mind, and those considerations I will, with your permission, very briefly state. We live in an age of great scientific progress. Inventions and discoveries succeed each other with remarkable rapidity, and for that reason increased scientific culture has become at once indispensable and more popular than it ever was before. We see that in every trade, in every profession, in every class of society, and I think this Institution may not unreasonably congratulate itself upon having for more than forty years taken the lead in that movement in the direction of scientific culture, which has added so much to the resources and strength of our country. We see that movement on every side of us. In the elementary schools, children are being taught some rudiments of science. It is the same in our great public schools; it is the same in the Universities; it is the same in the large centres of trade and commerce; and, last of all, it is the same,—and that in the highest possible degree,—in the Army and Navy. People are no longer content with that very one-sided literary education which sufficed in former days; and they begin to see that it is necessary to supplement what at one end of the ladder used to be called the three R's, and what at the other end of the ladder, used to be called elegant scholarship, with something more practical, more accurate, and more conducive to exact reasoning. This Institution has facilities for promoting scientific culture which perhaps no other Institution in the world has, for this reason, that we have here a neutral territory between science on the one hand and professional and practical life upon the other. The merits of the one frame of mind dovetail with the merits of the other; each corrects the faults of the other; and I think you get a more practical use of science in an Institution like this, than perhaps you do under any other conceivable circumstances.

I will not sit down without referring to the connection which has so long subsisted between the War Department and this Institution. I am happy to say that that connection is one on which both the War Department and the United Service Institution may reflect with pleasure. There has never been any approach to dependence between the two, but there has always been the utmost goodwill. We feel that we gain not only by the use made by Officers connected with the War Department of your valuable premises and of those facilities which you offer to them; but we feel that we gain in that wide diffusion of cultivated spirit which no Act of Parliament and no regulations can produce, but which the spontaneous efforts of this Institution have succeeded in very firmly establishing. My Lords and Gentlemen, I have only to thank you for having allowed me to occupy the Chair to-day, and to assure you it will be a great pleasure to me to look back upon my introduction to this Institution.

DONATION.

Captain W. P. Paine, 5th Surrey Rifle Volunteers, £2 12*s*.

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WHO JOINED THE INSTITUTION BETWEEN THE 9TH JULY AND 31ST DECEMBER, 1872.

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Imlach, R. W., Lieut.-Col. Georgetown Mil.
Daly, R. T. A., Lieut.-Col. Georgetown Mil.
Walker, Edward N., Capt. Georgetown Mil.
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Littleton, Hon. Algernon C., Lieut. R.N.
Barton, R. J., Lieut. 9th Lancers.
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Barnard, John H., Lieut. 19th Regt.
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Sankey, Wm., Colonel 62nd Regt.
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Draper, Edward T., Navy Agent.
Littledale, F. C. H., Lieut. 29th Regt.
Fraser, Chas. C., V.C., CB., Col. 11th Hussars.
Heathcote, Henry F., Lieut. 103rd Regt.
Browne, W. B., Lieut. 46th Regt.
De la Poer, R. H., Lieut. 15th Regt.
Pidcock, Henry H. F., Lt. 103rd Regt.
Cornish, Charles O., Capt. 18th Royal Irish.
Fillingham, Charles A., Lt. 65th Regt.
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Moore, Geo. Peter, Captain North Durham Mil.
Allison, James J., Major North Durham Mil.
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Pead, Leonard W., Lieut. Suffolk Art. Mil.
Turner, Wm. Webb, Captain 3rd Sussex Art. Vols.
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Carr, Ralph E., Major 36th Regt.
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Haslewood, Clement A., Lieut. 12th Middx. Rifle Vols.
Sedgwick, Leonard, Lieut. Royal Flint Mil.

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Comerford, James W., Capt. 22nd Middx. Rifle Vols.
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Chawner, Harry, Lieut. Georgetown Mil.
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Hope, Charles, Lieut. 60th Rifles.
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Stone, W. Harry, Capt. Roy. So. Gloucester Mil.
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Gamlen, W. B., Ensign 23rd Middx. Rifle Vols.
Ibbetson, C. V., Lt. 4th Dragoon Gds.
Thornton, C. E., Major late S. O. of Pensioners.
Howitt, M. B., Capt. 3rd R. Surrey Mil.
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Fox, L. Loftus B., Capt. Roy. Longford Rifle Mil.
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Bury, J. T., Lieut. R.A.
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2875. Seto Uchi or Inland Sea.

SECTION 14.

1016. Australia:—Bass Strait to Gabo Island.

New Zealand:—

719. Dusky and Breaksea Sounds, Middle Island.
720. Preservation and Chalky Inlets, Middle Island.

SECTION 15.

Pacific:—

767. Paumotu or Low Archipelago.
765. Union Group of Islands.
766. Ellis Islands, South-east Group of.
980. Caroline Islands.
731. Gilbert Islands, with Plans.
983. Marshall Islands

SECTION 16.

Tide Tables, 1873.
Lists of Lights, 1873, 10 in number.

The Lords Commissioners of the Admiralty.

Purchased.

Maps to illustrate current events, viz.:—

The Looshai Expedition.
Dr. Livingstone's Route.
The Autumn Manœuvres.
The Indian Raid on Orange Walk.
The San Juan Boundary.
Central Asia, &c.

MUSEUM.

MILITARY.

Presented.

Sword of Honour voted by the Patriotic Fund at Lloyd's to T. Pendergras, Esq., commanding H. E. I. Company's ship "Hope," one of the Fleet which, on the 15th Feb., 1804, drove off a squadron of French Men-of-War under the command of Admiral Linois, in the "Marengo," of 84 guns, as recorded in the "London Gazette" of August 11th, 1804.

Major J. G. Clarke, late 68th Light Infantry.

Five Javelins and two Arrows from Port McKay, Queensland.

Rear-Admiral Sir John Hay, Bt., C.B., M.P.

A suit of Japanese Armour.

Maj.-Gen. Henry W. Whitfield.

A Powder Horn, Scalping Knife, and a Pair of Mocassins taken from the body of an Indian in the War of Independence, 1776, by Major Gull, 35th Regiment.

G. P. S. Camden, Esq.

Specimens of Pebble, Spherical, Pellet, Prismatic, Russian, Waltham Abbey, and Curtis and Harvey's Powders for Heavy Ordnance,
F. A. Abel, Esq., F.R.S.

Medal awarded annually to the Best Shot in the Army.
H.R.H. the Field-Marshal Comg.-in-Chief.

An Indian Sword, Malay Kris, and Goorka Knife, with Belt.
Mrs. Martin.

Felt Helmet, worn by the Royal Artillery in 1854. *Major Sandilands, R.A.*

Two Japanese Swords.
Captain Whitla, 10th Regt.

4 Bows; 14 Arrows, cane barbed; 2 reed, iron barbed; 1 reed, wood barbed; 1 reed, plain; 1 reed Spear for Fishing; from British Guiana.
T. Hounslow, Esq.

Tomahawk, Bow, and 5 Arrows; 2 Chief's Pipe-Staves, from North America. *K. R. Murchison, Esq.*

MISCELLANEOUS.

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A set of Projectiles for the Whitworth 12-pr. Muzzle and Breech-loading Field Guns, viz.: one rifled sphere; one solid shot best form for flight; one common shell 3½ diameters long; one section of do., fitted with Pettman's concussion fuze; one section of shrapnel-shell; one section of case-shot; steel shell for penetrating armour and passing through water.
Sir Joseph Whitworth & Co.

A coloured Print of Whitehall Yard. No date.
Harold Dillon, Esq.

Harrison's Horse Shoes, sample of each, fore and hind; Cavalry, Good-enough's; Artillery, Fullerd's.
E. J. Harrison, Esq.

Specimens of Fusees and Rotatory Match for old American Rifle and Cartridge, before the War of 1859–60.
Colonel Hon. E. Legge.

The Game of War.
Captain Gillett.

The first Shell fired by the Russians at the Alma, picked up by Assist.-Surg. Thompson, 46th Regt., who gave it to Staff Commander G. Reid, R.N.
Staff-Comr. G. Reid, R.N.

A small French Eagle, from a Battle-field in the Peninsula War.
Mrs. Martin.

Silk Punkah with Silver Stick, taken from the Rajah of Bhurtpore at the storming of that place, and given by Colonel Caines, late Lieut.-Governor of Hong-Kong, to Madam Von Gumpach, whose father, Brigadier-General Edwards (who commanded the 14th Foot), was killed at the capture of that fortress.
Madam Von Gumpach.

"The Tottenham" Soldiers' Scoop, Pick, and Rifle Rest; 5 Specimens, showing the latest improvement in Construction.
Major Tottenham, Bengal S. Corps.

Photographs of a Monument, erected in Surat Cemetery in 1865, by the Officers, Non-commissioned Officers, and Men of the 56th Regt., to the Memory of those of the Regiment who died in Guzerat from 1809 to 1814.
Capt. M. C. Garsia.

Coloured Cast, from the original in the Whinchopp Collection, of a Tooth of gigantic extinct Shark, found in the red clay of Suffolk (Carchrodon Megalodon of Agassiz).
Edward Charlesworth, Esq.

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Lieut. W. H. Richards, R.N.

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Model of a New Zealand Canoe.
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Capt. Aug. Phillimore, R.N.

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Photographs of Eight missing Atlantic Steamers.
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Models (quarter-size) of the 35-ton Gun, 8-inch Howitzer, and Steel 9-pr. Field Gun, with their respective Shot and Shell.

TOPOGRAPHICAL MODELS.

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The Kriegsspiel, or War Game.
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[MAY, 1873.]

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